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Region III
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Total Maximum Daily Load For Nutrients Deep Run, Beach Run, and Elizabeth Run Watersheds

June 2004

Draft Report

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Executive Summary

Introduction

As required by Section 303(d) of the Clean Water Act and current EPA regulations, states are required to develop Total Maximum Daily Loads (TMDLs) for waterbodies that exceed water quality standards. Deep Run, Beach Run, and Elizabeth Run were listed on the Pennsylvania 1996 List of Impaired Waters (DEP, 1996) because of water quality violations of the streams designated uses. Deep Run, Beach Run, and Elizabeth Run are located in the northeast section of Lebanon County, in central Pennsylvania. Deep Run, Beach Run, and Elizabeth Run are part of the same drainage network; Elizabeth Run is formed by the confluence of Deep Run and Beach Run. These streams are tributaries of Little Swatara Creek, in the lower Susquehanna River Basin.

Impairment Listing

Stream segments in the Deep Run, Beach Run, and Elizabeth Run watersheds were first reported as impaired on Pennsylvania's 1996 Section 303(d) List of Impaired Waters. Additional segments and impairment sources were subsequently added on Pennsylvania's 1998 and 2004 Section 303(d) lists. Stream segments in the watersheds are listed as impaired for sediment, nutrients, and unknown pathogens. The analyses and results presented in this report establish nutrient TMDLs for Deep Run, Beach Run, and Elizabeth Run. Sediment TMDLs established for Deep Run, Beach Run, and Elizabeth Run are addressed in a separate report. TMDLs for unknown pathogens are scheduled to be completed by 2017.

Watershed Characterization and Environmental Monitoring

The Deep Run and Beach Run watersheds are approximately 1,442 acres (2.3 square miles) and 2,717 acres (4.2 square miles), respectively. The Elizabeth Run watershed, which encompasses both the Deep Run and Beach Run watersheds, is approximately 6,322 acres (9.9 square miles). The land use, topography, soils, and other physical characteristics of the three watersheds are very similar. Therefore, the three watersheds were combined for the purposes of data presentation, and the combined watershed is

referred to as the Deep-Beach-Elizabeth Run watershed. The watershed is highly agricultural; the dominant land uses are hay/pastureland (64%) and row crops (16%), which account for a combined 80% of the land area in the Deep-Beach-Elizabeth Run watershed. The majority of the watershed is comprised of Berks-Weikert-Bedington soils. Berks-Weikert-Bedington soils are gently sloping to very steep, shallow and moderately deep, well-drained soils on hills and ridges, and are characterized as the type 'C' hydrologic soils group.

Environmental monitoring data were vital to the identification of the sources of nutrients that are impacting water quality conditions in Deep Run, Beach Run, and Elizabeth Run. Available monitoring data included instream water quality collected at 9 monitoring stations on Deep Run, Beach Run, and Elizabeth Run, groundwater data from monitoring wells, and discharge monitoring reports (DMR) from the 5 permitted point sources present in the watershed. Instream monitoring data showed nitrate concentrations were elevated throughout the watershed; the lowest concentrations were observed at the headwater stations, and concentrations were elevated in the lower reaches of Deep Run (20.6 mg/L) and Beach Run (11.1 mg/L), and in Elizabeth Run (17.3 mg/L). Phosphorus concentrations were also lowest in the headwaters and elevated in the downstream reaches of the watershed. The highest observed phosphorus concentrations were observed at the mouth of Deep Run (648 µg/L) and the upper reaches of Elizabeth Run (538 µg/L).

Farmer's Pride Poultry was the only permitted facility for which effluent nitrate data was available. Nitrate + nitrite concentrations in effluent discharged from Farmer's Pride Poultry exceeded 60 mg/L 37 times in 48 samples during the period of October 1999 to December 2003. Phosphorus concentrations in plant effluent were also high at some facilities. Discharged phosphorus concentrations at College Hill Poultry exceeded the 2 mg/L average monthly discharge limit 8 times in 48 samples, and on one occasion in fall 2000 exceeded 5 mg/L. Effluent phosphorus concentrations at the Fredericksburg WWTP also exceeded 2 mg/L 4 times in 48 samples.

Groundwater data was available at several monitoring wells associated with the permitted facilities in the watersheds. No violations of Pennsylvania's 10 mg/L source water

quality standard for nitrate were observed at wells associated with College Hill Poultry, Farmer's Pride Poultry, or the Fredericksburg Water Authority. Five violations of the source water quality standard for nitrate occurred at wells associated with the BC Natural Chicken facility. These violations occurred in January 1999, October of 2001 and 2002, and February and June of 2003. Additionally, observed nitrate concentrations in the BC Natural Chicken wells approached the 10 mg/L source water quality standard on several other occasions.

Nutrient Loading Determination

Nutrient loadings from land sources, groundwater, and septic systems were determined using the ArcView Generalized Watershed Loading Functions (AVGWLF) model. AVGWLF model simulations were performed for a 10 year period in order to account for seasonal and annual variations in hydrologic conditions. For each watershed, average annual nitrogen and phosphorus loads were computed for each source area based on the 10 year simulation period.

The annual point source loadings were computed based on mean discharge loading rates for ammonia and total phosphorus obtained from DMR data from the permitted facilities. Only one of the five facilities, Farmer's Pride Poultry, monitors effluent nitrate concentrations. The instream data and groundwater well data indicated that there is a significant nitrate load to Deep Run, Beach Run, and Elizabeth Run in the area surrounding the permitted facilities. Therefore, to establish a conservative estimate of total nitrate loading from point sources, it was assumed that all five facilities were discharging effluent nitrate in concentrations similar to those observed at the Farmer's Pride facility. The nutrient loads under existing conditions for Deep Run, Beach Run, and Elizabeth Run were computed as the total loading from land sources, groundwater, septic systems, and point sources.

The QUAL2K model was used to link the nutrient loads generated for Deep Run, Beach Run, and Elizabeth Run in AVGWLF and loading from point sources to instream water quality conditions. The QUAL2K model was used to simulate summer dry weather conditions under steady state flow conditions. QUAL2K models were developed for both

the watershed mainstem, defined as the headwaters of Deep Run to the mouth of Elizabeth Run, and the Beach Run watershed, defined as Beach Run from its headwaters to its mouth. Non-point and point source nutrient loads from Beach Run modeled using AVGWLF were represented as discreet loads input to the stream mainstem. Input headwater data for the QUAL2K models was based on observed instream water quality and flow data.

TMDL Endpoint Determination

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. The Pennsylvania potable drinking water nitrate standard of 10 mg/L was used as the nitrate TMDL endpoint for the Deep Run, Beach Run, and Elizabeth Run TMDLs. Currently Pennsylvania does not have numeric criteria for phosphorus; because of the relationship between phosphorus loading and dissolved oxygen concentrations, the Pennsylvania instantaneous dissolved oxygen criteria of 4 mg/L was used as the endpoint for the Deep Run, Beach Run, and Elizabeth Run phosphorus TMDLs.

Nitrate

The Pennsylvania potable drinking water nitrate standard of 10 mg/L at the nearest drinking water intake was used as the nitrate TMDL endpoint for the Deep Run, Beach Run, and Elizabeth Run TMDLs. Observed and modeled nitrate concentrations exceeded the 10 mg/L nitrate water quality standard at several points in Deep Run, Beach Run, and Elizabeth Run. However, the nearest drinking water intake, the Pennsylvania American Water Company, is 28 miles downstream, and is located on Swatara Creek near Hershey, Pennsylvania.

Analysis of the available flow data indicated that there is considerable dilution between the mouth of Elizabeth Run and the drinking water intake on Swatara Creek. The observed flow at the mouth of Elizabeth Run was approximately 10 cubic feet per second (cfs). The closest flow monitoring station on Swatara Creek to the drinking water intake was USGS station 015733560, Swatara Creek near Hershey, Pennsylvania. Mean stream

flow at this station was approximately 1003 cfs. Due to the dilution occurring between the mouth of Elizabeth Run and the drinking water intake, the nitrate loads contributed from Deep Run, Beach Run, and Elizabeth Run are negligible with respect to nitrate concentrations at the drinking water intake. Additionally, water quality data collected at USGS station 01573560 from the available period of record of 1984-1994 indicated that mean nitrate concentrations in Swatara Creek at this station were generally between 3-4 mg/L, and did not exceed 7 mg/L in any of the observed samples. This indicates that nitrate concentrations at the drinking water intake are below 10 mg/L, and thus do not violate the potable drinking water standard. For these reasons, TMDLs for nitrate were not required for Deep Run, Beach Run, and Elizabeth Run.

Phosphorus

The linkage between instream nutrient levels, algae and dissolved oxygen concentrations was established by running the QUAL2K model under the dry weather, low flow condition, when elevated nutrient levels exert their largest influence on dissolved oxygen concentrations (Dodds, 2002). The maximum allowable phosphorus concentrations that did not violate the instantaneous dissolved oxygen criteria of 4 mg/L in Deep Run, Beach Run, and Elizabeth Run were used as the target phosphorus concentrations upon which TMDL allocations were based. The target phosphorus concentration in Deep Run and Elizabeth was 337 µg/L, and the target phosphorus concentration in Beach Run was 257 µg/L. Reduction of phosphorus loading to these levels is expected to allow Deep Run, Beach Run, and Elizabeth Run to achieve their designated uses.

TMDL Allocation

Phosphorus TMDL allocations for Deep Run, Beach Run, and Elizabeth Run were based on the following equation.

$$TMDL = WLA + LA + MOS$$

Where:
TMDL= Target Phosphorus Concentrations under TMDL Endpoint
WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The wasteload allocation represents the total nutrient loading allocated to point sources. The load allocation represents the total nutrient loading allocated to non-point sources. A margin of safety is applied to account for uncertainty in methodologies and determination of nutrient loadings. An implicit margin of safety was used in the Deep Run, Beach Run, and Elizabeth Run TMDLs.

Phosphorus TMDL Allocation

The target phosphorus concentrations under the dry weather, critical condition are identified in Section 4.0. It is important to recognize that these target concentrations were developed under specific conditions which include the following:

- Permitted facilities are discharging at their design capacities
- Permitted facilities are discharging BOD, phosphorous, and ammonia at their maximum permitted levels
- Permitted facilities effluent DO concentrations only meet the minimum permit requirements

The combination of these factors resulted in target phosphorous concentrations that are very stringent and would require substantial load reduction from point and non-point sources of phosphorous in the watersheds. Since it is not likely that all of these conditions will coexist in the watersheds, several scenarios to reduce permitted BOD,

increase the DO concentration in the effluent, or simply maintain the status loading were assessed. Using the QUAL2K model, additional loading scenarios were evaluated. These additional loading scenarios examined the impacts of other water quality parameters that influence the maximum allowable phosphorus concentrations that do not violate Pennsylvania's dissolved oxygen criteria. These allocation scenarios are presented in Section 5.0. Final TMDL allocation scenarios will be chosen after discussions with and in consultation with representatives from various state and local agencies, watershed stakeholders, and the public.

Tentative TMDL allocations are presented in Section 5.0. The proposed allocations for Deep Run and Elizabeth Run are based upon a scenario representing the facilities discharging at their permitted limits under existing effluent flow conditions. The proposed allocation for Beach Run is based upon a scenario representing a reduction of BOD in the discharge effluent of the permitted point sources to 15 mg/L under design flow conditions. It is emphasized that these are tentative scenarios, with the final TMDL allocations to be determined after input from watershed stakeholders, state and local agencies, and the public.

No reductions are required in Deep Run, Beach Run, and Elizabeth Run under the proposed allocation scenarios. Achieving the dissolved oxygen instantaneous standard for Deep Run and Beach Run under the proposed allocation scenario requires the permitted facilities to maintain their discharge rates at their current levels. To attain dissolved oxygen standards in Beach Run under the proposed allocation scenario, BOD levels must be kept at 15 mg/L under design flow conditions. The phosphorus TMDLs for Deep Run, Beach Run, and Elizabeth Run are shown in Table E-1, Table E-2, and Table E-3, respectively. The proposed TMDL allocations and the percent reduction required for all watershed sources are presented in Tables E-4 to E-6. Tables E-7 and E-8 present the BOD reduction and facility effluent dissolved oxygen concentrations necessary for each of the permitted facilities under the proposed allocation scenarios.

Table E-1: Proposed Phosphorus TMDL for Deep Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety
15700.4	3767.1	11933.2	Implicit

Table E-2: Proposed Phosphorus TMDL for Beach Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety
4640.6	3728.7	911.9	Implicit

Table E-3: Proposed Phosphorus TMDL for Elizabeth Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety (10%)
1593.8	1593.8	0.0	Implicit

Table E-4: Proposed TMDL Allocations for Deep Run

Source	Land Use Type	Deep Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	23.1	23.1	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	312.2	312.2	0
	Row Crop	303.4	303.4	0
	Low Intensity Residential	0.02	0.02	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.02	0.02	0
Septic Systems	-	0.0	0.0	0
Groundwater	-	2127.4	2127.4	0
Point Sources	-	6716.3	6716.3	0
Total		9482.7	9482.7	0

Table E-5: Proposed TMDL Allocations for Beach Run

Source	Land Use Type	Beach Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	93.7	93.7	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	446.5	446.5	0
	Row Crop	896.7	896.7	0
	Low Intensity Residential	0.0	0.0	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.0	0.0	0
Septic Systems	-	1.9	1.9	0
Groundwater	-	2289.6	2289.6	0
Point Sources	-	885.4	885.4	0
Total		4614.1	4614.1	0

Table E-6: Proposed TMDL Allocations for Elizabeth Run

Source	Land Use Type	Elizabeth Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	0.0	0.0	0
	Evergreen Forest	Not present	Not present	0
	Mixed Forest	0.0	0.0	0
	Pasture/Hay	695.9	695.9	0
	Row Crop	274.5	274.5	0
	Low Intensity Residential	0.4	0.4	0
	High Intensity Residential	0.2	0.2	0
	Commercial/Industrial	0.1	0.1	0
Septic Systems	-	3.8	3.8	0
Groundwater	-	619.0	619.0	0
Point Sources	-	0.0	0.0	0
Total		1593.8	1593.8	0

Table E-7: Dissolved Oxygen Reductions Required Under Allocation Scenarios 4 and 7

Allocation Scenario	Facility Name	Flow Condition	Permitted Effluent Dissolved Oxygen (mg/L)	Proposed Effluent Dissolved Oxygen (mg/L)
4	College Hill Poultry	Design	5	7
	Keystone Protein Company	Design	5	7
7	BC Natural Chicken	Existing	5	5
	Farmer's Pride Poultry	Existing	5	5
	Fredericksburg Wastewater Treatment Plant	Existing	5	5

Table E-8: BOD Reductions Required Under Allocation Scenarios 4 and 7

Allocation Scenario	Facility Name	Flow Condition	Permitted Effluent BOD (mg/L)	Proposed Effluent BOD (mg/L)	BOD Percent Reduction
4	College Hill Poultry	Design	40	15	63
	Keystone Protein Company	Design	40	15	63
7	BC Natural Chicken	Existing	40	40	0
	Farmer's Pride Poultry	Existing	40	40	0
	Fredericksburg Wastewater Treatment Plant	Existing	40	40	0

Implementation

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Deep Run, Beach Run, and Elizabeth Run TMDLs identify the necessary overall load reductions for nutrients currently causing use impairments and distribute those reduction goals to the appropriate sources. Reaching the reduction goals established by these TMDLs will only occur through changes in current land use practices, including the incorporation of best management practices (BMPs), and monitoring to ensure that discharge effluent from permitted point sources does not exceed permitted or allocated standards.

The relative contribution of nutrients varies throughout the watershed according to the distribution of land use sources such as row crop and pasture lands, as well as the location of permitted point sources. Implementation of best management practices in the watershed should reduce the non-point source loads of nutrients to levels that achieve the loading reduction goals established in these TMDLs. Further ground-truthing should be performed in order to determine the most cost-effective and environmentally protective combination of BMPs required for meeting the nutrient reductions outlined in this report.

Public Participation

Watershed stakeholders will have opportunities to provide input and to participate in the development of the TMDLs. A public meeting will be held on June 29, 2004 in the town of Fredericksburg, Pennsylvania. Stakeholders will have the opportunity to comment on the draft TMDL report, pollutant loadings, and the proposed allocation scenarios.

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1.0 Introduction

1.1 Regulatory Guidance

Section 303(d) of the Clean Water Act and the Environmental Protection Agency's (EPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for waterbodies that are exceeding water quality standards. TMDLs represent the total pollutant loading that a waterbody can receive without violating water quality standards. The TMDL process establishes the allowable loadings of pollutants for a waterbody based on the relationship between pollution sources and instream water quality conditions. By following the TMDL process, states can establish water quality based controls to reduce pollution from both point and non-point sources to restore and maintain the quality of their water resources (EPA, 2001).

The state regulatory agency for Pennsylvania is the Department of Environmental Protection (DEP). As required by the Clean Water Act, Pennsylvania DEP develops and maintains a listing of all impaired waters in the state that details the pollutant(s) exceeding water quality standards and the potential source(s) of each pollutant. This list is referred to as the Section 303(d) list. As part of the settlement of a TMDL lawsuit in Pennsylvania[1], EPA agreed to develop or approve TMDLs for waters included on Pennsylvania's 1996 Section 303(d) List of Impaired Waters under a specified timeframe. The TMDLs in this report were developed in partial fulfillment of that lawsuit and address three streams on Pennsylvania's 1996 Section 303(d) list, Deep Run, Beach Run, and Elizabeth Run, located in Lebanon County.

1.2 Impairment Listing

Deep Run, Beach Run, and Elizabeth Run are located in the northeast section of Lebanon County, in central Pennsylvania. Deep Run, Beach Run, and Elizabeth Run are part of the same drainage network; Elizabeth Run is formed by the confluence of Deep Run and Beach Run. These streams are tributaries of Little Swatara Creek, in the lower

[1] *American Littoral Society and Public Interest Research Group of Pennsylvania v. EPA*

Susquehanna River Basin. A map depicting the location of Deep Run, Beach Run, and Elizabeth Run is presented in Figure 1-1.

Stream segments in the Deep Run, Beach Run, and Elizabeth Run watersheds (located in Pennsylvania State Water Plan 7-D) were first reported as impaired on Pennsylvania's 1996 Section 303(d) List of Impaired Waters. Additional segments and impairment sources were subsequently added on Pennsylvania's 1998 and 2004 Section 303(d) lists. Each stream segment in these watersheds is identified by a unique code, referred to as a stream code. The stream codes for each stream segment in Deep Run, Beach Run, and Elizabeth Run are presented in Figure 1-2, and will be used to describe the impairment listings for these streams. All stream segments in Deep Run, Beach Run, and Elizabeth Run are currently listed as impaired.

The full impairment listings for Deep Run, Beach Run, and Elizabeth Run are discussed below in Section 1.2.1. Stream segments in the watersheds are listed as impaired for sediment, nutrients, and unknown pathogens. The analyses and results presented in this report establish nutrient TMDLs for Deep Run, Beach Run, and Elizabeth Run. Sediment TMDLs and loading reductions for Deep Run, Beach Run, and Elizabeth Run are provided in a separate TMDL report. TMDLs for stream segments impaired by pathogens are scheduled to be completed by 2017.

1.2.1 Impaired Segment Listings

The 4 stream segments comprising Beach Run (stream codes 9898-9901) were reported on Pennsylvania's 1998 Section 303(d) list as impaired due to siltation from storm sewers and urban runoff. One segment of Deep Run (stream code 9896) was reported on the 1996 Section 303(d) list as impaired from the segment mouth to 0.9 miles upstream due to nutrients and sediment from agricultural and point sources. The remainder of this segment (from 0.9 miles upstream of the mouth to 2.7 miles upstream) was reported as impaired on the 1998 Section 303(d) list. The other stream segment (stream code 9897) in Deep Run was reported on the 1998 Section 303(d) list as impaired due to nutrients and sediment from agricultural and urban sources. Both stream segments in Deep Run were also reported as impaired due to pathogens from unknown sources on the 2004

Section 303(d) list; a TMDL for this impairment is scheduled to be completed by the year 2017.

In addition to the stream segments comprising Deep Run and Beach Run, 5 additional stream segments comprise the Elizabeth Run watershed. Stream code 9891 was first listed as impaired for nutrients and sediment on the 1996 Section 303(d) list, which stated that the impairment was due to point sources. In 1998 the listing for this segment was updated to include agriculture as a source of impairment in addition to point sources. This stream segment was also reported on the 2004 Section 303(d) list as impaired due to pathogens from unknown sources; a TMDL for this impairment is scheduled to be completed by the year 2017. The remaining 4 stream segments in Elizabeth Run (stream codes 9892-9895) were reported on the 1998 Section 303(d) list as impaired due to nutrients and sediment from agricultural sources.

As stated above, this report addresses only the nutrient impairment present in Deep Run, Beach Run, and Elizabeth Run and establishes nutrient TMDLs for these streams. Sediment TMDLs established for Deep Run, Beach Run, and Elizabeth Run are addressed in a separate report. TMDLs for unknown pathogens are scheduled to be completed by 2017.

Figure 1-1: Location of the Deep Run, Beach Run, and Elizabeth Run Watersheds

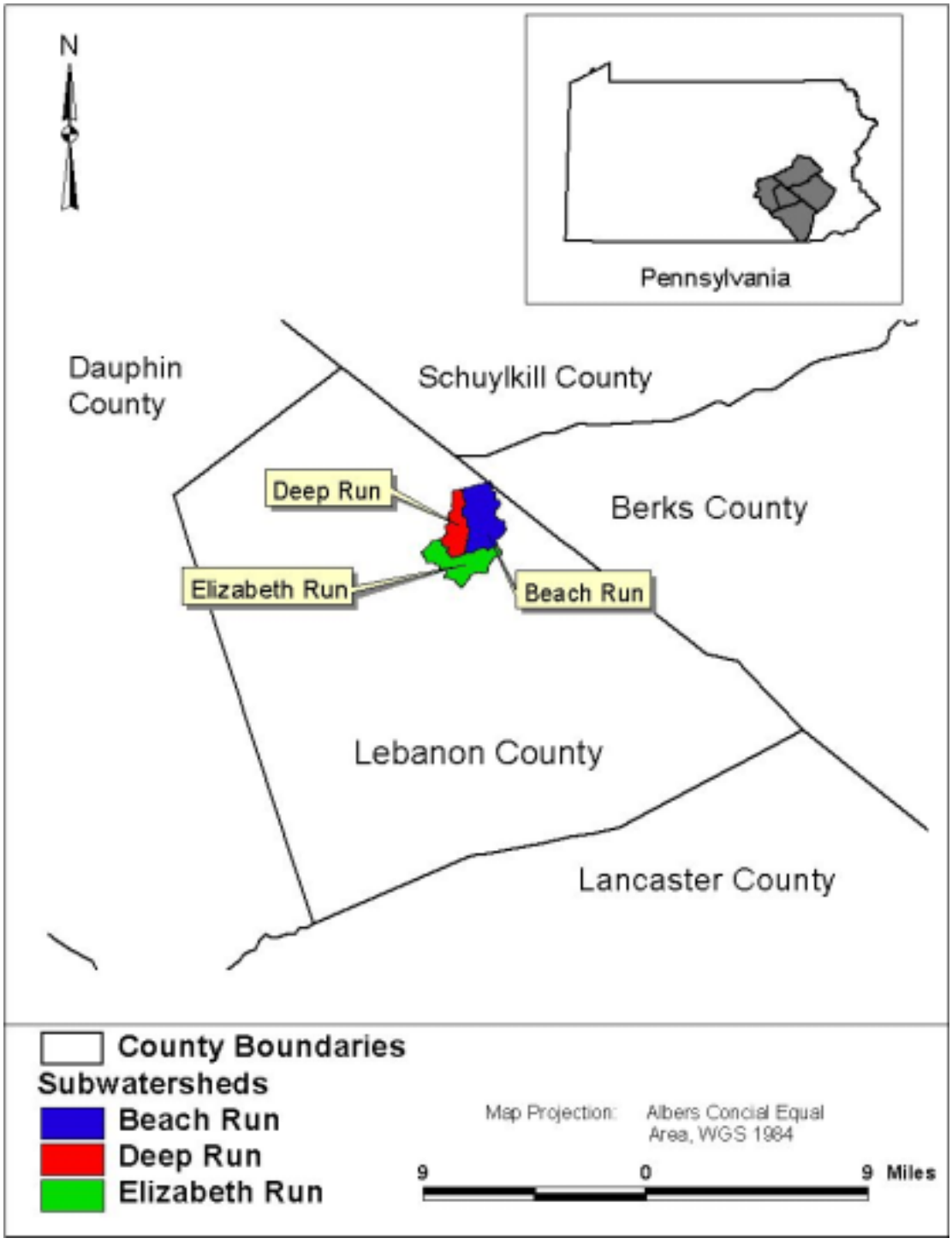
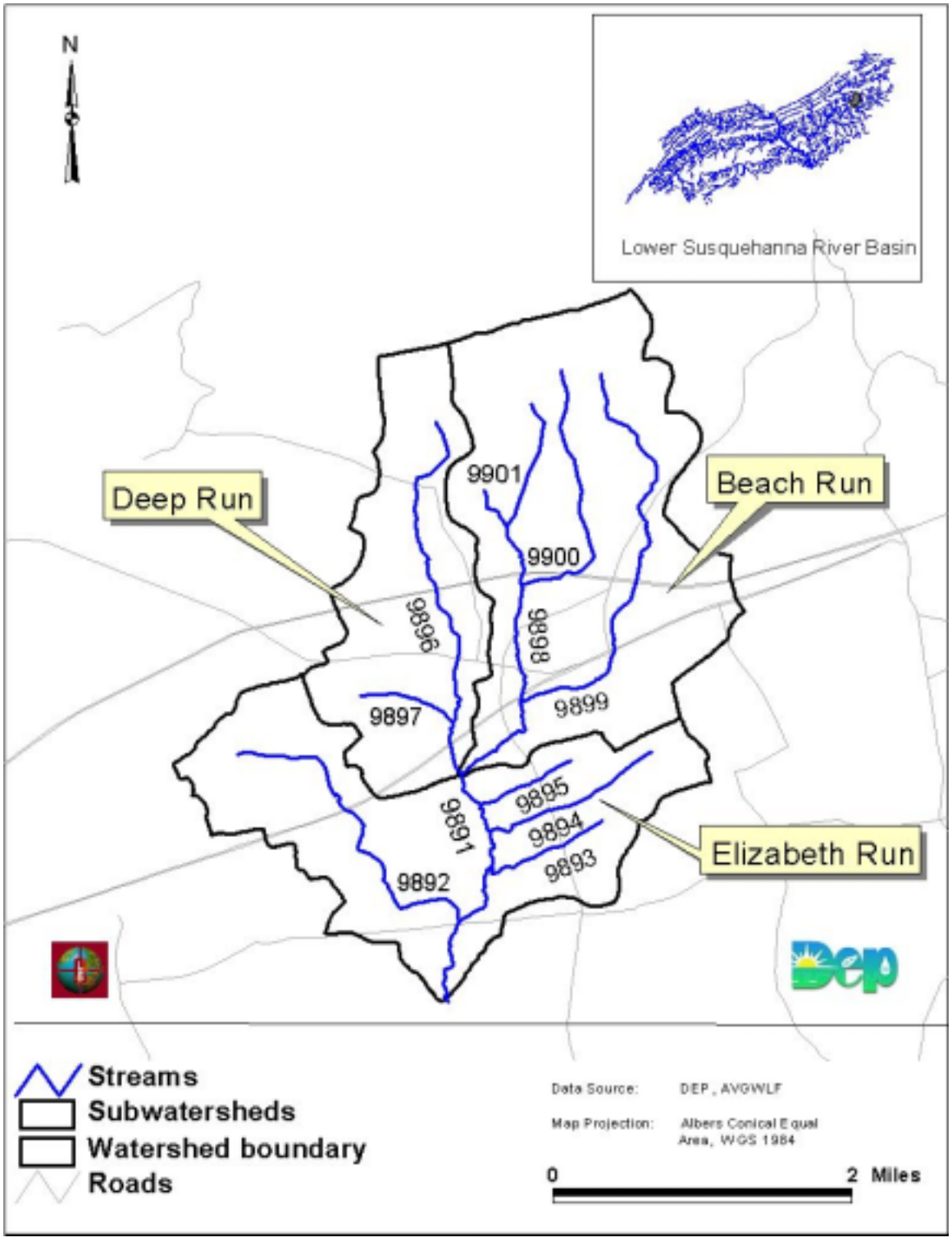


Figure 1-2: Stream segments in Deep Run, Beach Run, and Elizabeth Run



1.3 Applicable Water Quality Standard

Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses. Water quality standards consist of designated uses for a waterbody and water quality criteria necessary to support those designated uses, as well as an antidegradation section. According to Pennsylvania Water Quality Standards, the term *water quality criteria* are defined as "numeric concentrations, levels or surface water conditions that need to be maintained or attained to protect existing and designated uses."

1.3.1 Designated Uses

Pennsylvania Water Quality Standards (§ 93.3 of the Code of Pennsylvania) designate water uses which shall be protected, and upon which the development of water quality criteria shall be based. These include the protection of potable water supplies as defined by the Federal Safe Drinking Water Act (42 U.S.C.A. § 300F), or by other water users that require a permit from the Department under the Pennsylvania Safe Drinking Water Act (35 P. S. § 721.1—721.18), as well as water supply for wildlife, industry, livestock, and irrigation. The maintenance and propagation of aquatic life, including coldwater and warmwater fisheries, and anadromous and catadromous fishes which ascend into flowing waters to complete their life cycle, are also protected as designated uses of Pennsylvania's waters. Pennsylvania Water Quality Standards also serve to designate waters in the state for primary contact recreation, fishing, boating, esthetics, and navigation.

1.3.2 Water Quality Criteria

1.3.2.1 Nutrient Criteria

Pennsylvania has developed specific water quality criteria (§ 93.7 of the Code of Pennsylvania) for nitrate plus nitrite, and ammonia. These specific water quality criteria state:

"Nitrate plus nitrite concentrations may not exceed 10 mg/L as nitrogen for waters used for potable water supply. Potable Water Supply constitutes water used by the public as defined by the Federal Safe Drinking Water Act, 42 U.S.C.A. § 300F, or by other water

users that require a permit from the Department under the Pennsylvania Safe Drinking Water Act (35 P. S. § § 721.1—721.18), or the act of June 24, 1939 (P. L. 842, No. 365) (32 P. S. § § 631—641), after conventional treatment, for drinking, culinary and other domestic purposes, such as inclusion into foods, either directly or indirectly."

And

"The maximum total ammonia nitrogen concentration at all times shall be the numerical value given by un-ionized ammonia nitrogen (NH3-N) x (log-1[pKT-pH] + 1), where:

un-ionized ammonia nitrogen = 0.12 x f(T)/f(pH), f(pH) = 1 + 101.03(7.32-pH), f(T) = 1, T ›= 10°C, f(T) = 1 + 10(9.73-pH) , T ‹ 10°C, 1 + 10(pKT-pH), and pKT = the dissociation 0.090 + constant for ammonia in water."

"The average total ammonia nitrogen concentration over any 30 consecutive days shall be less than or equal to the numerical value given by un-ionized ammonia nitrogen (NH3-N) x (log-1[pKT-pH] + 1), where:

un-ionized ammonia nitrogen = 0.025 x f(T)/f(pH), f(pH) = 1, pH ›= 7.7, f(pH) = 100.74(7.7-pH), pH ‹ 7.7, f(T) = 1, T ›= 10°C, f(T) = 1 + 10(9.73-pH) , T ‹ 10°C, 1 + 10(pKT-pH)."

Pennsylvania has not currently established numeric water quality criteria for total nitrogen, or total phosphorus. In the absence of specific water quality criteria, the General Criteria defined by Pennsylvania provides a narrative criteria for the protection of a waterbodies designated uses.

1.3.2.2 General Criteria

The General Criteria defined in Pennsylvania's Water Quality Standards (§ 93.6 of the Code of Pennsylvania) provides general, narrative criteria for the protection of designated uses from substances that may interfere with attainment of such uses. The general water quality criteria state:

"Water may not contain substances attributable to point or non-point source discharges in concentration or amounts sufficient to be inimical or harmful to the water uses to be protected or to human, animal, plant or aquatic life. In addition to other substances listed within or addressed by this chapter, specific substances to be controlled include, but are not limited to, floating materials, oil, grease, scum and substances which produce color, tastes, orders, turbidity or settle to form deposits."

1.4 TMDL Development for Deep Run, Beach Run, and Elizabeth Run

TMDL development requires a methodology to confirm impairment causes identified in the Section 303(d) list and to determine pollutant reductions that will allow the streams to attain their designated uses. Nutrients, sediment, and pathogens were identified as the cause of the impairment in Deep Run, Beach Run, and Elizabeth Run. This report addresses the nutrient impairment and establishes nutrient TMDLs for Deep Run, Beach Run, and Elizabeth Run.

In the subsequent sections of this report, watershed and environmental monitoring data used in TMDL development for these streams are discussed and analyzed. Sources of nutrients in the watershed are described and analyzed. After reviewing the available watershed and environmental monitoring data, a technical approach was developed and used to estimate mass loading rates of nutrients to the streams. A modeling approach was used to determine the maximum allowable phosphorus concentrations that did not violate the TMDL endpoint in Deep Run, Beach Run, and Elizabeth Run. These approaches and calculations are presented in Sections 3.0 and 4.0 of this TMDL report. TMDL allocations for Deep Run, Beach Run, and Elizabeth Run are presented in Section 5.0. Finally, reasonable assurance and implementation for these TMDLs is discussed in Section 6.0, and public participation is discussed in Section 7.0.

2.0 Watershed Characterization

In this section, the types of data available and the information collected for TMDL development for Deep Run, Beach Run, and Elizabeth Run are presented. This information was used to characterize these streams and their watersheds, and to inventory and characterize the potential point and non-point sources of nutrients in the watershed.

2.1 Data and Information Inventory

Data and information used to characterize these streams and to inventory and identify the potential point and non-point sources of nutrients in the watershed are presented in Table 2-1, and are described below. Many of these data were available as part of the ArcView Generalized Watershed Loading Functions (AVGWLF) model developed for Pennsylvania, which was used in TMDL development. Categories of data that were used include:

(1) Watershed physiographic data that describe the watershed physical conditions such as topography, soils, and land use.

(2) Hydrographic data that describe the stream physical conditions, such as the stream reach network and connectivity, and the stream channel depth, width, and slope.

(3) Data and information related to the use and activities in the watershed that can be used to identify potential nutrient sources.

(4) Environmental monitoring data that describe water quality conditions in the streams, in the groundwater, and in the effluent of permitted facilities that contribute to stream flow.

Table 2-1: Descriptions and Sources of Data used in TMDL Development

Data Category	Description	Potential Source(s)
Watershed physiographic data	Watershed boundary	DEP
	Land use/land cover	NLCD, MRLC, AVGWLF
	Soil data (STATSGO)	NRCS, AVGWLF
	Topographic data (USGS 10 meter DEM, USGS Quads)	USGS, PASDA
Hydrographic data	Stream network and reaches	BASINS, AVGWLF
	Stream morphology	Field Measurements
Weather data	Hourly meteorological conditions	NCDC, AVGWLF
Watershed activities/ uses data	Livestock densities	PASS, AVGWLF
	Septic systems	U.S. Census Bureau, AVGWLF
Point sources and direct discharge data and information	Permitted facilities locations and discharge monitoring reports (DMR)	EPA Permit Compliance System (PCS), NPDES, DEP
Environmental monitoring data	Ambient in-stream monitoring data	DEP
	Stream flow data	USGS, DEP

Notes
AVGWLF: ArcView Generalized Watershed Loading Functions model
DEP: Pennsylvania Department of Environmental Protection
EPA: Environmental Protection Agency
MRLC: Multi-Resolution Land Characteristics consortium
NCDC: National Climatic Data Center
NLCD: National Land Cover Data
PASDA: Pennsylvania Spatial Data Access
PASS: Pennsylvania Agricultural Statistics Service
USGS: U.S. Geological Survey
NPDES: National Pollutant Discharge Elimination System

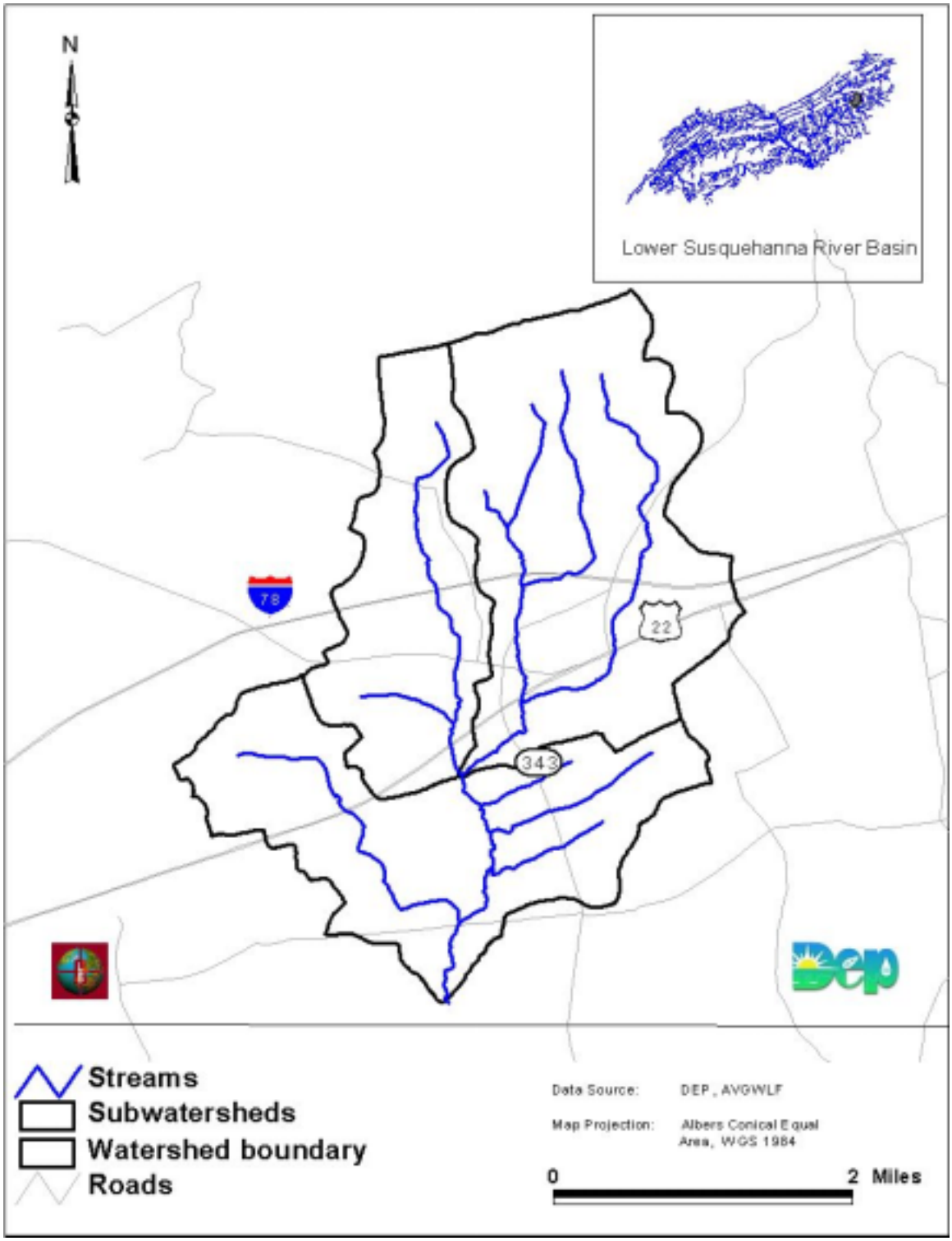
2.2 Watershed Description and Identification

2.2.1 Watershed Boundaries

Deep Run and Beach Run are tributaries of Elizabeth Run, which is a tributary of Little Swatara Creek in the Susquehanna River Basin. The Deep Run and Beach Run watersheds are approximately 1,442 acres (2.3 square miles) and 2,717 acres (4.2 square miles), respectively. The Elizabeth Run watershed is approximately 2,163 acres (3.4 square miles), and the entire basin, which encompasses the Deep Run, Beach Run, and Elizabeth Run watersheds, is approximately 6,322 acres (9.9 square miles). The land use, topography, soils, and other physical characteristics of the three watersheds are very similar. Therefore, the three watersheds were combined for the purposes of data presentation, and the combined basin is referred to as the Deep-Beach-Elizabeth Run watershed in the following sections.

The Deep-Beach-Elizabeth Run watershed is located in the northeast section of Lebanon County and makes up about 2.7 percent of the county's land area. U.S. Interstate highway 78 runs through the northern section of the watershed in an east to west direction, above the town of Fredericksburg. U.S. Route 22 runs through the central section of the watershed in a northeast to southwest direction, below the town of Fredericksburg. State road 343 runs from north to south through the central section of the watershed. Figure 2-1 is a map showing the location and the boundary of the watershed.

Figure 2-1: Location and Boundary of the Deep-Beach-Elizabeth Run Watershed



2.2.2 Topography

A 10-meter digital elevation model (DEM) and USGS 7.5 minute quadrangle maps were used to characterize the topography in the watershed. DEM data were obtained from the Pennsylvania Geospatial Data Clearinghouse and compared to the Lebanon County USGS 7.5 minute quadrangle maps. Elevation in the watershed ranged from 369 to 1,023 feet above sea level, with a mean elevation of 696 feet.

2.2.3 Soils

The Deep-Beach-Elizabeth Run watershed soil characterization was based on the State Soil Geographic (STATSGO) dataset, obtained from the AVGWLF model. There are two general soil associations located in the Deep-Beach-Elizabeth Run watershed: Berks-Weikert-Bedington and Hazleton-DeKalb-Buchanan. The majority of the watershed is comprised of Berks-Weikert-Bedington soils. Berks-Weikert-Bedington soils are gently sloping to very steep, shallow and moderately deep, well-drained soils on hills and ridges. Hazleton-DeKalb-Buchanan soils are deep and moderately deep soils formed in material weathered from acid sandstone, quartzite, and conglomerate. The distribution of soils in the Deep-Beach-Elizabeth Run watershed is presented in Table 2-2.

Table 2-2: Soil Types and Characteristics in the Deep-Beach-Elizabeth Run Watershed

Map Unit ID	Soil Association	Percent	Hydrologic Soil Group
PA022	HAZLETON-DEKALB-BUCHANAN	12	C
PA033	BERKS-WEIKERT-BEDINGTON	88	C

Source: AVGWLF

The hydrologic soil group linked with each soil association is also presented in Table 2-2. The hydrologic soil groups represent the different levels of infiltration capacity of the soils. Hydrologic soil group “A” designates soils that are well to excessively well drained, whereas hydrologic soil group “D” designates soils that are poorly drained. This means that soils in hydrologic group “A” allow a larger portion of the rainfall to infiltrate

and become part of the ground water system. On the other hand, compared to the soils in hydrologic group "A", soils in hydrologic group "D" allow a smaller portion of the rainfall to infiltrate and become part of the ground water. Consequently, more rainfall becomes part of the surface water runoff. Descriptions of the hydrologic soil groups are presented in Table 2-3. The Deep-Beach-Elizabeth Run watershed soils are characterized by moderate to slow infiltration rates.

Table 2-3: Descriptions of Hydrologic Soil Groups

Hydrologic Soil Group	Description
A	High infiltration rates. Soils are deep, well drained to excessively drained sand and gravels.
B	Moderate infiltration rates. Deep and moderately deep, moderately well and well-drained soils with moderately coarse textures.
C	Moderate to Slow infiltration rates. Soils with layers impeding downward movement of water or soils with moderately fine or fine textures.
D	Very slow infiltration rates. Soils are clayey, have high water table, or shallow to an impervious cover

2.2.4 Land Use

Land use characterization was based the National Land Cover Data (NLCD), developed by USGS. The distribution of land uses in the Deep-Beach-Elizabeth Run watershed, by land area and percentage, is presented in Table 2-4. The watershed is highly agricultural; the dominant land uses are hay/pastureland (64%) and row crops (16%), which account for a combined 80% of the land area in the Deep-Beach-Elizabeth Run watershed. A comparison of land use percentages in the Deep Run, Beach Run, and Elizabeth Run watersheds is presented in Table 2-5. Brief descriptions of the land use classifications are presented in Table 2-6.

Figure 2-2 depicts the land use distribution within the watershed. The majority of the basin is agricultural. There is a band of forested land in the northern headwaters of the watershed. The town of Fredericksburg, located in the central section of the watershed, just above the confluence of Deep Run and Beach Run, represents the main developed area in the watershed.

Table 2-4: Land Use Distribution in the Deep-Beach-Elizabeth Run Watershed

Land Use Category	Land Use Type	Acres	Percent of Watershed's Land Area
Water/Wetlands	Open Water	20.0	0.3
	Woody Wetlands	12.3	0.2
	Emergent Herbaceous Wetlands	26.4	0.4
Developed	Low Intensity Residential	120.5	1.9
	High Intensity Residential	23.9	0.4
	Commercial/Industrial/Transportation	138.1	2.2
Agriculture	Pasture/Hay	4030.4	63.7
	Row Crop	1008.6	16.0
Forest	Deciduous Forest	772.1	12.2
	Evergreen Forest	71.4	1.1
	Mixed Forest	98.8	1.6
Total		**6,322**	**100**

Table 2-5: Percent of Land Use Types in the Deep Run, Beach Run, and Elizabeth Run Watersheds

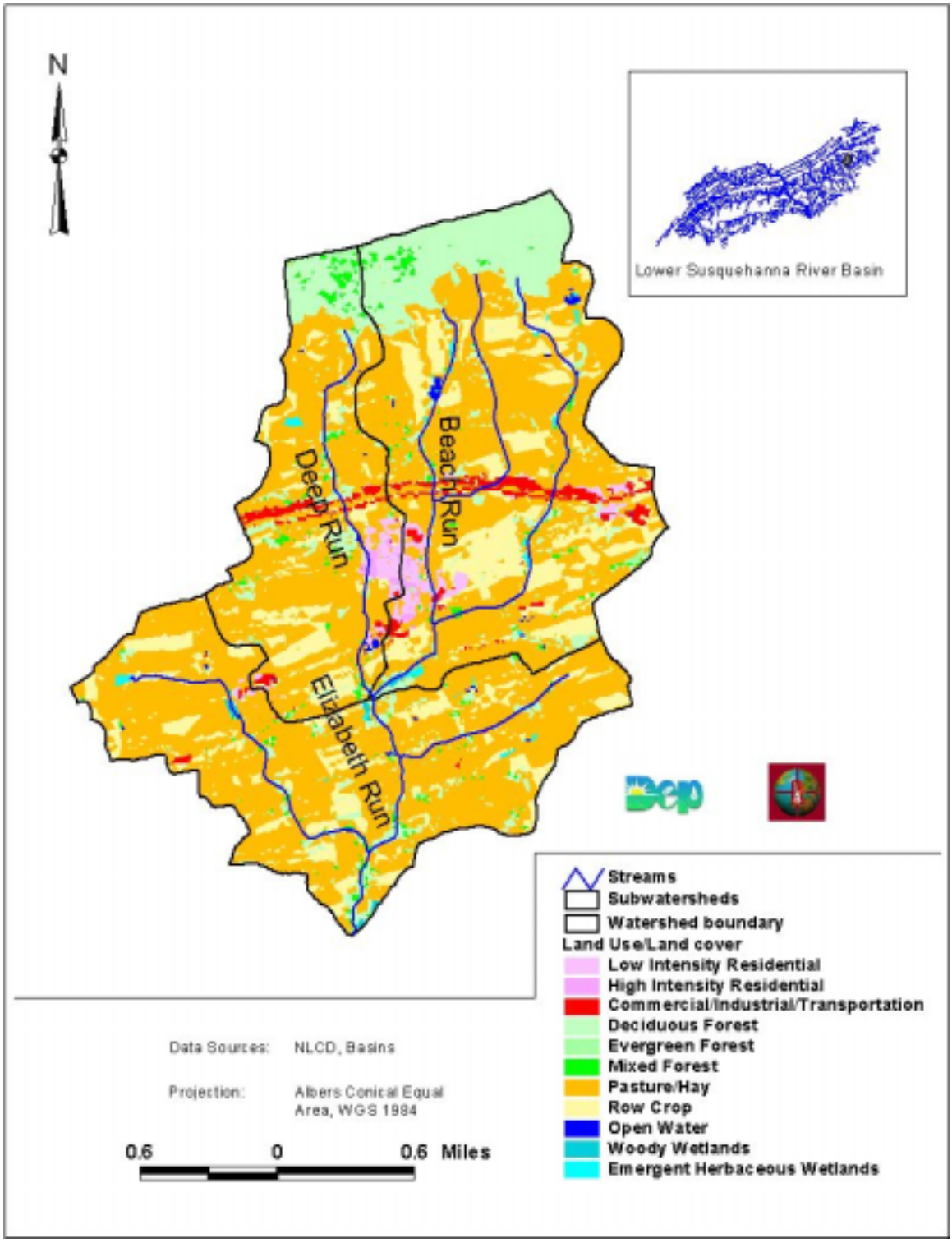
Land Use Category	Land Use Type	% of Deep Run Watershed	% of Beach Run Watershed	% of Elizabeth Run Watershed
Water/Wetlands	Open Water	0.3	0.4	0.2
	Woody Wetlands	0.0	0.1	0.4
	Emergent Herbaceous Wetlands	0.3	0.5	0.4
Developed	Low Intensity Residential	3.2	2.6	0.2
	High Intensity Residential	1.0	0.4	Not present
	Commercial/Industrial/Transportation	3.0	3.2	0.3
Agriculture	Pasture/Hay	62.2	54.2	76.6
	Row Crop	13.3	18.2	14.9
Forest	Deciduous Forest	12.1	18.1	4.9
	Evergreen Forest	1.9	1.0	1.8
	Mixed Forest	2.7	1.3	1.2
Total		**100**	**100**	**100**

Table 2-6: Descriptions of Land Use Types

Land Use Type	Description
Open Water	Areas of open water, generally with less than 25 percent or greater cover of water
Woody Wetlands	Areas where forest or shrubland vegetation accounts for 25-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for 75-100 percent of the cover and the soil or substrate is periodically saturated with or covered with water.
Low Intensity Residential	Includes areas with a mixture of constructed materials and vegetation. Constructed materials account for 30-80 percent of the cover. Vegetation may account for 20 to 70 percent of the cover. These areas most commonly include single-family housing units. Population densities will be lower than in high intensity residential areas.
High Intensity Residential	Includes heavily built up urban centers where people reside in high numbers. Examples include apartment complexes and row houses. Vegetation accounts for less than 20 percent of the cover. Constructed materials account for 80-100 percent of the cover.
Commercial/Industrial/ Transportation	Includes infrastructure (e.g. roads, railroads, etc.) and all highways and all developed areas not classified as High Intensity Residential.
Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.
Row Crop	Areas used for the production of crops, such as corn, soybeans, vegetables, tobacco, and cotton.
Deciduous Forest	Areas dominated by trees where 75 percent or more of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	Areas characterized by trees where 75 percent or more of the tree species maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	Areas dominated by trees where neither deciduous nor evergreen species represent more than 75 percent of the cover present.

Source: NLCD

Figure 2-2: Land Use in the Deep-Beach-Elizabeth Run Watershed



2.3 Monitoring Data

2.3.1 Stream Flow Data

There is no stream flow gauge or other source of stream flow data present in the Deep-Beach-Elizabeth Run watershed.

2.3.2 Instream Water Quality Monitoring

No ambient water quality monitoring stations are present in the Deep-Beach-Elizabeth Run watershed. However, in support of TMDL development, the DEP Southcentral Regional office conducted bi-weekly sampling at monitoring stations within the watershed, beginning the week of March 29th 2004. Water quality parameters sampled include flow, dissolved oxygen, temperature, pH, conductivity, nitrate, nitrite, total phosphorus, and total suspended solids. Sampling stations were located at the mouth of the streams and downstream of the point sources in the watershed to identify and characterize the pollutant loadings from each source. Descriptions of the monitoring stations within the Deep-Beach-Elizabeth Run watershed are given in Table 2-7, and the locations of these stations are depicted in Figure 2-3.

Three rounds of sampling were conducted by DEP at each station in the Deep-Beach-Elizabeth Run watershed, with the exception of stations E1, E2, and D2, for which only two rounds of samples were collected. Mean concentrations for each of the parameters monitored at the 9 stations in the watershed are presented in Table 2-8.

Nitrate concentrations were elevated throughout the watershed; the lowest concentrations were observed at headwater stations D2 and B4, and concentrations were elevated in the lower reaches of Deep Run (20.6 mg/L) and Beach Run (11.1 mg/L), and in Elizabeth Run (17.3 mg/L). Ammonia concentrations were also elevated in the lower reaches of the streams, with mean observed ammonia concentrations of 643 µg/L at the mouth of Deep Run, 80 µg/L at the mouth of Beach Run, and 95 µg/L at the mouth of Elizabeth Run. Kjeldahl nitrogen concentrations were below analytical detection limits at most monitoring stations. Phosphorus concentrations were also lowest in the headwaters and elevated in the downstream reaches of the watershed. The highest observed phosphorus

concentrations were observed at the mouth of Deep Run (648 µg/L at station D1) and the upper reaches of Elizabeth Run (538 µg/L at station E3).

Total suspended solids concentrations were highest in the upper reaches of Beach Run (24.7 mg/L at station B4) and Elizabeth Run (22.7 mg/L at station E3). Mean suspended solids concentrations ranged from 9 mg/L to 14 mg/L at the other water quality monitoring stations. Dissolved oxygen, biochemical oxygen demand, pH, and temperature values remained relatively constant throughout the Deep-Beach-Elizabeth Run watershed. No violations of Pennsylvania water quality criteria for dissolved oxygen, pH, or temperature were observed in the data collected at the 9 monitoring stations.

Table 2-7: In-stream Water Quality Monitoring Stations Located in the Deep-Beach-Elizabeth Run Watershed

Station Number	Stream Name	Station Location
E1	Elizabeth Run	Mouth, above confluence with Little Swatara Creek.
E2	Elizabeth Run	At confluence with unnamed tributary, approximately 0.6 miles upstream of mouth.
E3	Elizabeth Run	Below confluence of Beach Run and Deep Run.
D1	Deep Run	Mouth, above confluence with Beach Run.
D2	Deep Run	Above Interstate I-78 and the Farmer's Pride facility.
B1	Beach Run	Mouth, above confluence with Deep Run.
B2	Beach Run	Confluence with unnamed tributary, approximately 0.7 miles upstream of mouth.
B3	Unnamed Tributary to Beach Run	Mouth, below the Keystone Protein facility.
B4	Beach Run	Confluence with unnamed tributary, above the College Hill facility.

Figure 2-3: In-stream Water Quality Monitoring Stations in the Deep-Beach-Elizabeth Run Watershed

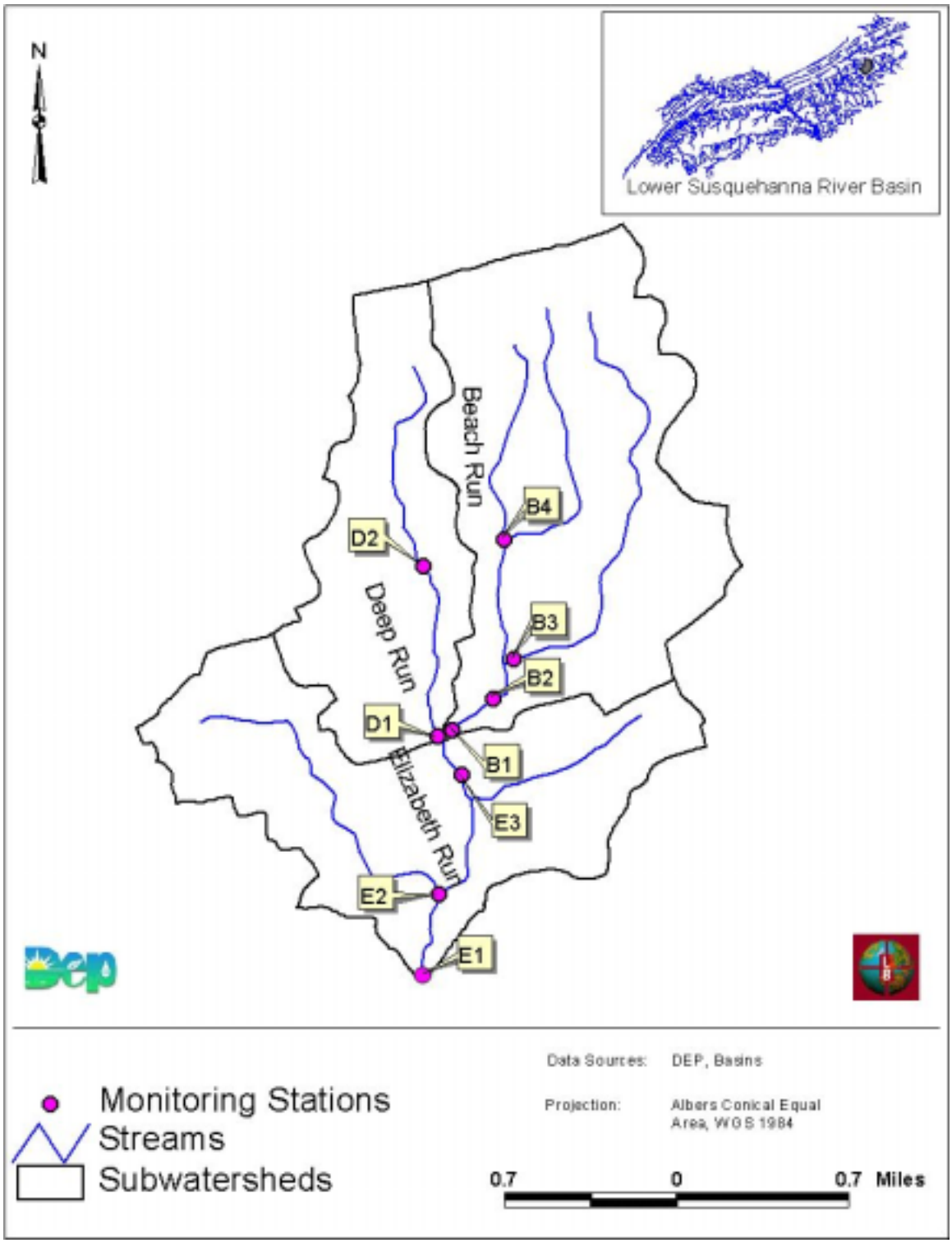


Table 2-8: Mean Water Chemistry Concentrations for Parameters Monitored in the Deep-Beach-Elizabeth Run Watershed

Water Chemistry Parameter	Water Quality Monitoring Stations								
	Beach Run				Deep Run		Elizabeth Run		
	B1	B2	B3	B4	D1	D2	E1	E2	E3
Alkalinity (mg/L)	67.0	67.5	74.1	38.7	103.1	40.0	100.2	102	85.7
Ammonia (µg/L)	80	110	25	20	643	30	95	35	23
BOD5 (mg/L)	1.5	1.4	1.2	1.0	1.4	1.4	1.7	1.3	2.5
Chloride (mg/L)	38.0	39.6	36.7	18.9	110.4	26.5	62.1	20.1	71.8
Dissolved Oxygen (mg/L)	11.6	12.5	12.8	10.9	9.8	10.0	11.3	10.9	10.4
Stream Flow (cfs)	7.3	8.1	2.9	3.6	5.1	1.9	10.4	3.9	13.4
Kjeldahl Nitrogen (mg/L)	BD	BD	BD	BD	1.6	BD	BD	BD	0.9
Nitrate (mg/L)	11.1	11.2	16.2	3.7	20.6	4.9	17.3	10.6	14.6
Nitrite (mg/L)	0.1	0.1	0.0	0.0	0.1	0.0	0.1	0.1	0.1
pH	8.2	8.2	8.4	7.3	7.8	7.4	8.2	8.0	7.9
Phosphorus (µg/L)	110	110	52	44	648	36	340	84	538
Temperature (degrees Celcius)	13.5	12.6	13.4	12.1	14.0	15.0	13.8	11.2	13.6
Total Suspended Solids (mg/L)	13.3	12.7	20	24.7	11.3	14.0	13.0	9.0	22.7
BD: Below analytical detection limits.									

2.3.3 Permitted Point Sources

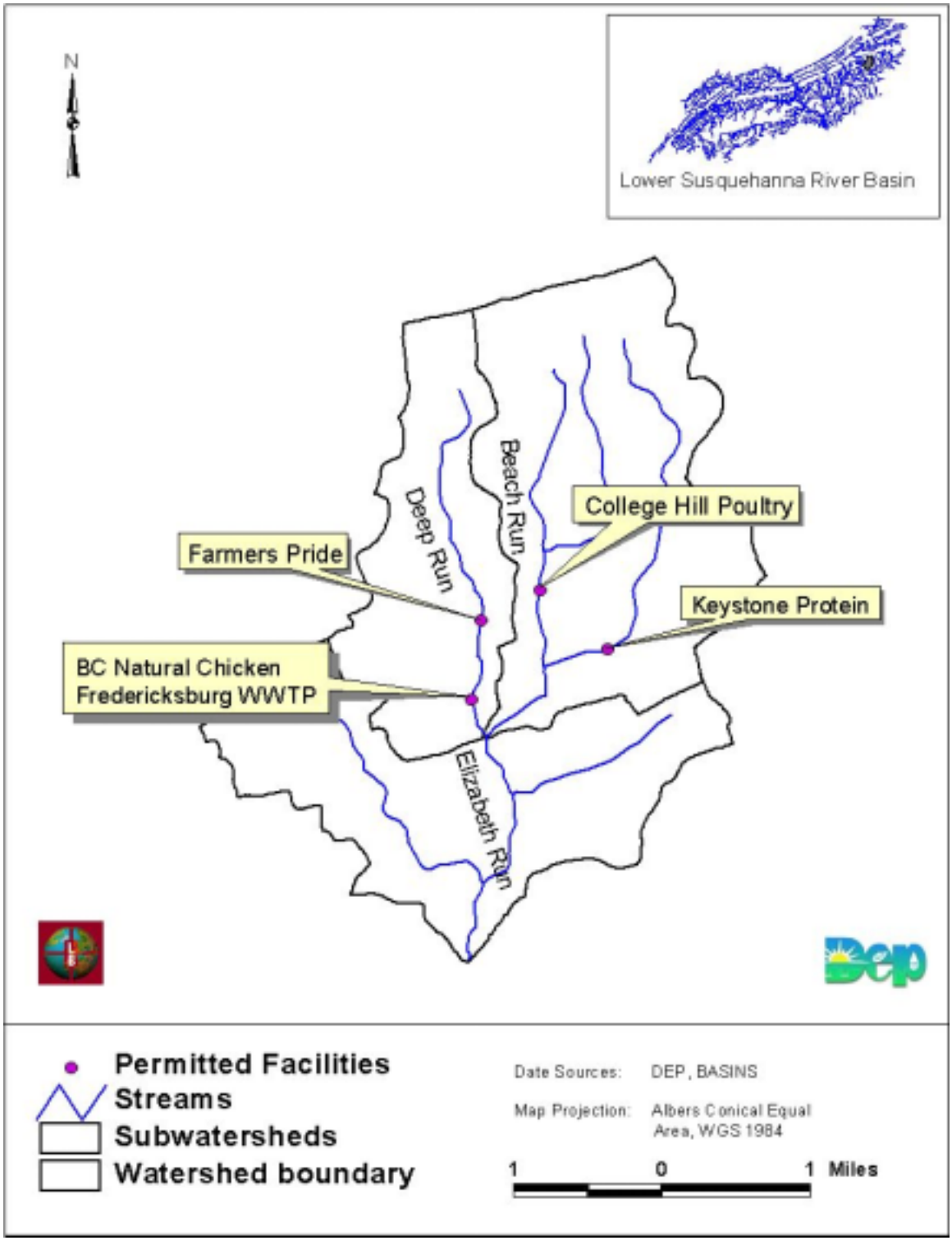
Data obtained from the DEP Southcentral Regional office indicated that there are five permitted facilities located in the Deep-Beach-Elizabeth Run watershed. These include three poultry processing facilities, a protein rendering facility, and the town of Fredericksburg Wastewater Treatment Plant (WWTP). The location of these facilities is depicted in Figure 2-4. The permit number, receiving waterbody, design flow, and status of each of these facilities are presented in Table 2-9. It should be noted that the BC Natural Chicken facility was operated by Pennfield Farms until August 2003, when the Pennfield Corporation sold its meat poultry division to BC Natural Chicken. Although much of the available data was collected prior to this transaction, for the purposes of this report all data collected at this facility is reported under the name BC Natural Chicken.

Table 2-9: Permitted Dischargers in the Deep-Beach-Elizabeth Run Watershed

Permit Number	Facility Name	Receiving Waterbody	Design Flow (gpd)[1]	Status
PA0080829	Keystone Protein Company	Beach Run	250,000	Active
PA0024228	BC Natural Chicken	Deep Run	600,000	Active
PA0035157	Farmer's Pride Poultry	Deep Run	900,000	Active
PA0008010	College Hill Poultry	Beach Run	150,000	Active
PA0080705	Fredericksburg Wastewater Treatment Plant	Deep Run	150,000	Active

1. gpd: gallons per day

Figure 2-4: Location of Permitted Facilities



Discharge monitoring reports (DMR) for the permitted facilities were available from December 1999 to December 2003. Data for the monitored parameters are presented in Figure 2-5 through Figure 2-13. Average monthly flows were highest at BC Natural Chicken and Farmer's Pride Poultry, ranging from 0.21 to 0.60 and from 0.37 to 0.56 MGD (million gallons per day) at these two facilities, respectively. Elevated effluent ammonia concentrations were observed at most facilities, with the exception of Keystone Protein Company. Spikes in ammonia discharge were observed at College Hill Poultry in the summer and fall 2000 and spring 2001, at BC Natural Chicken in spring 2001, and at Farmer's Pride Poultry in spring 2003. Ammonia concentrations were also elevated in effluent discharged from the Fredericksburg WWTP on several occasions, and violated the average monthly ammonia discharge limit 8 times from 2001 to 2003. Farmer's Pride Poultry was the only permitted facility for which effluent nitrate data was available. Nitrate + nitrite concentrations in effluent discharged from Farmer's Pride Poultry exceeded 60 mg/L 37 times in 48 samples during the period of October 1999 to December 2003.

Phosphorus concentrations in plant effluent were also high at some facilities. Discharged phosphorus concentrations at College Hill Poultry exceeded the 2 mg/L average monthly discharge limit 8 times in 48 samples, and on one occasion in fall 2000 exceeded 5 mg/L. Effluent phosphorus concentrations at the Fredericksburg WWTP also exceeded 2 mg/L 4 times in 48 samples. Measured phosphorus concentrations in effluent discharged from Farmer's Pride Poultry and BC Natural Chicken typically ranged between 1 mg/L to 2 mg/L. Effluent discharged by Keystone Protein Company contained less than 1 mg/L of phosphorus in all observed measurements.

The available dissolved oxygen data indicated that monthly average concentrations at all the permitted facilities did not drop below Pennsylvania's minimum daily average dissolved oxygen criteria of 5 mg/L for warm water fisheries. Daily average dissolved oxygen concentrations were not reported in the DMR data. All reported pH values at the facilities were within Pennsylvania's established pH criteria range of 6 to 9. Average monthly biochemical oxygen demand concentrations at the permitted facilities typically ranged from 3 mg/L to 7 mg/L from October 1999 to December 2003. Spikes in average

monthly biochemical oxygen demand concentrations were observed at College Hill Poultry and BC Natural Chicken in fall 2000 and spring 2001. Biochemical oxygen demand concentrations above 10 mg/L were also observed at College Hill Poultry and the Fredericksburg WWTP in fall 2000, and at BC Natural Chicken in fall 2003. Total suspended solids concentrations were generally low at all the permitted facilities, with the exception of some increased concentrations observed in 2000 and early 2001 at College Hill Poultry and the Fredericksburg WWTP.

Figure 2-5: Permitted Facilities - Average Monthly Flow

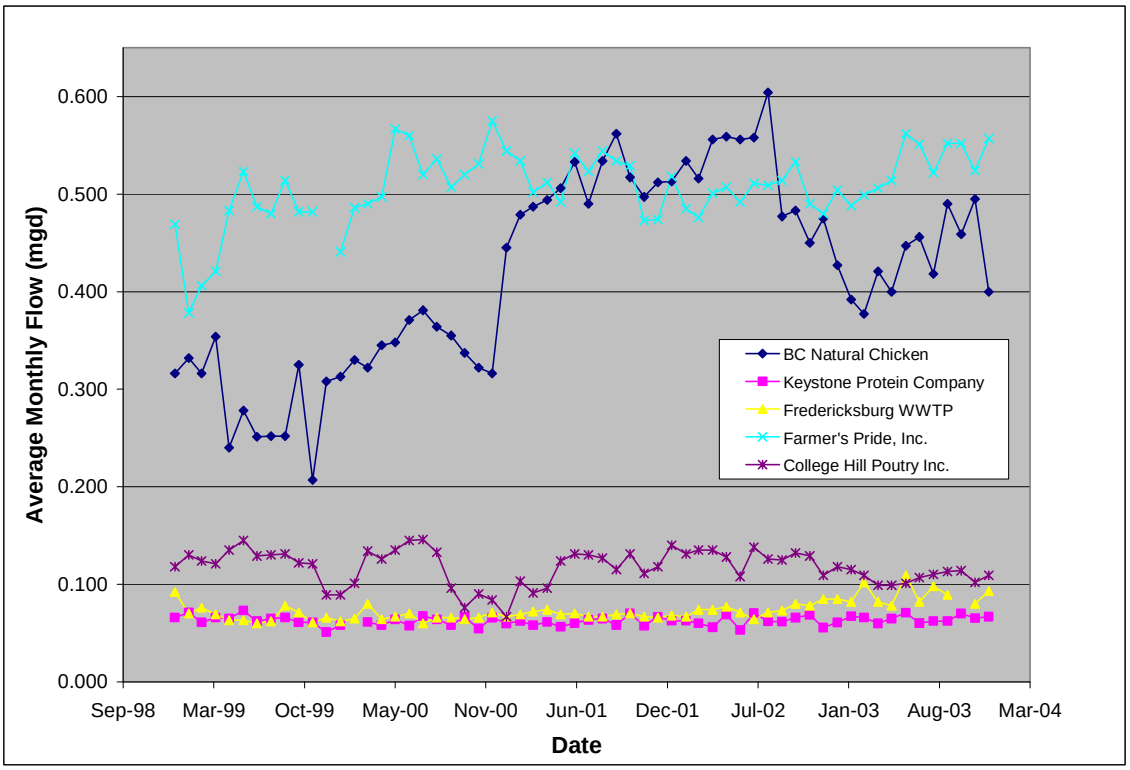


Figure 2-6: Permitted Facilities - Maximum Daily Flow

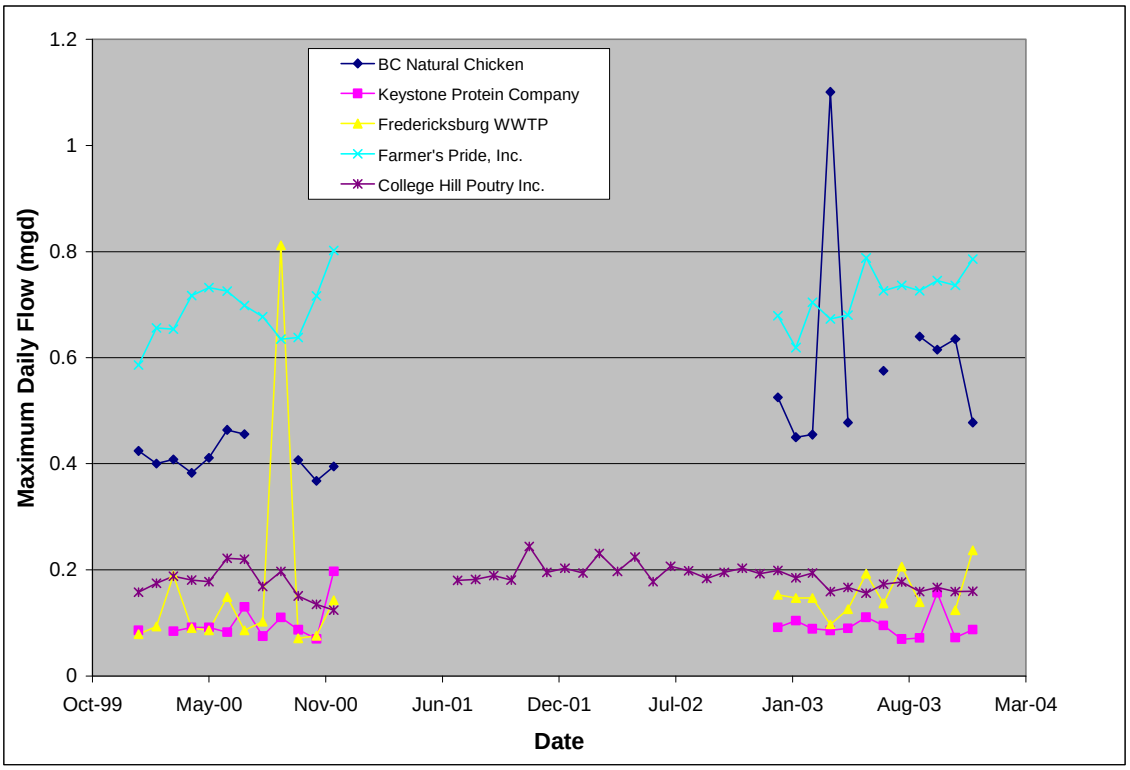


Figure 2-7: Permitted Facilities – Ammonia Concentrations

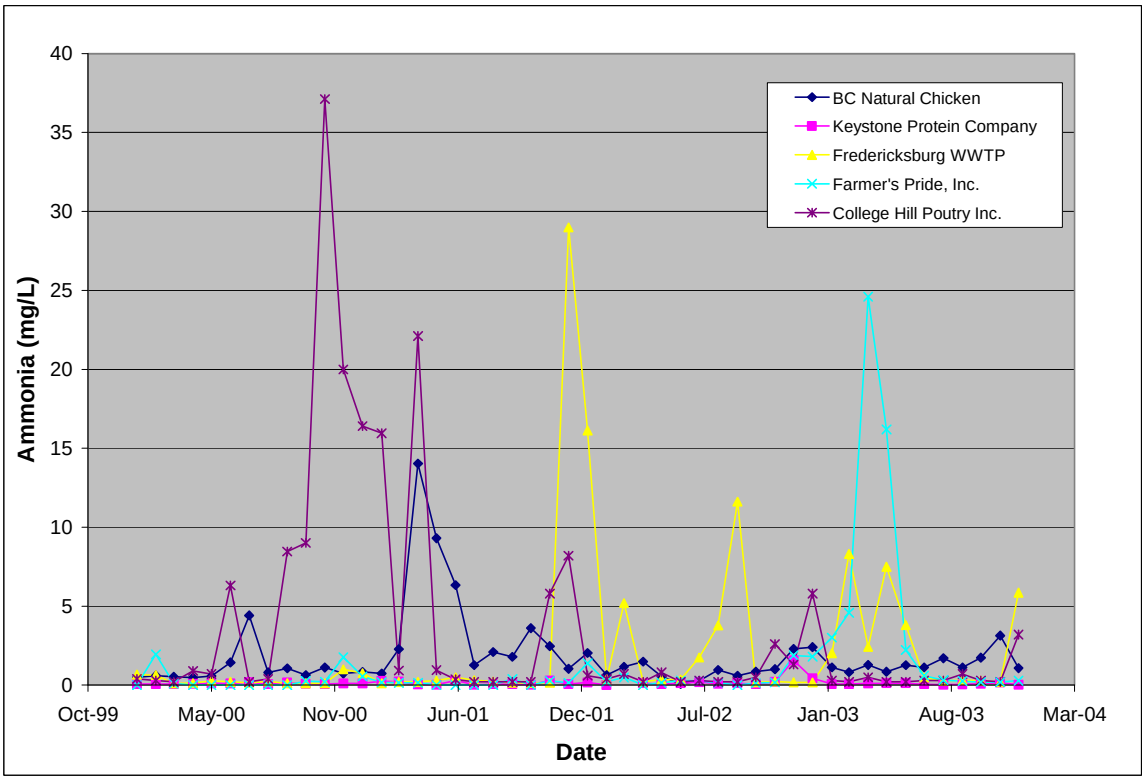


Figure 2-8: Farmer's Pride Poultry – Nitrate +Nitrite Concentrations

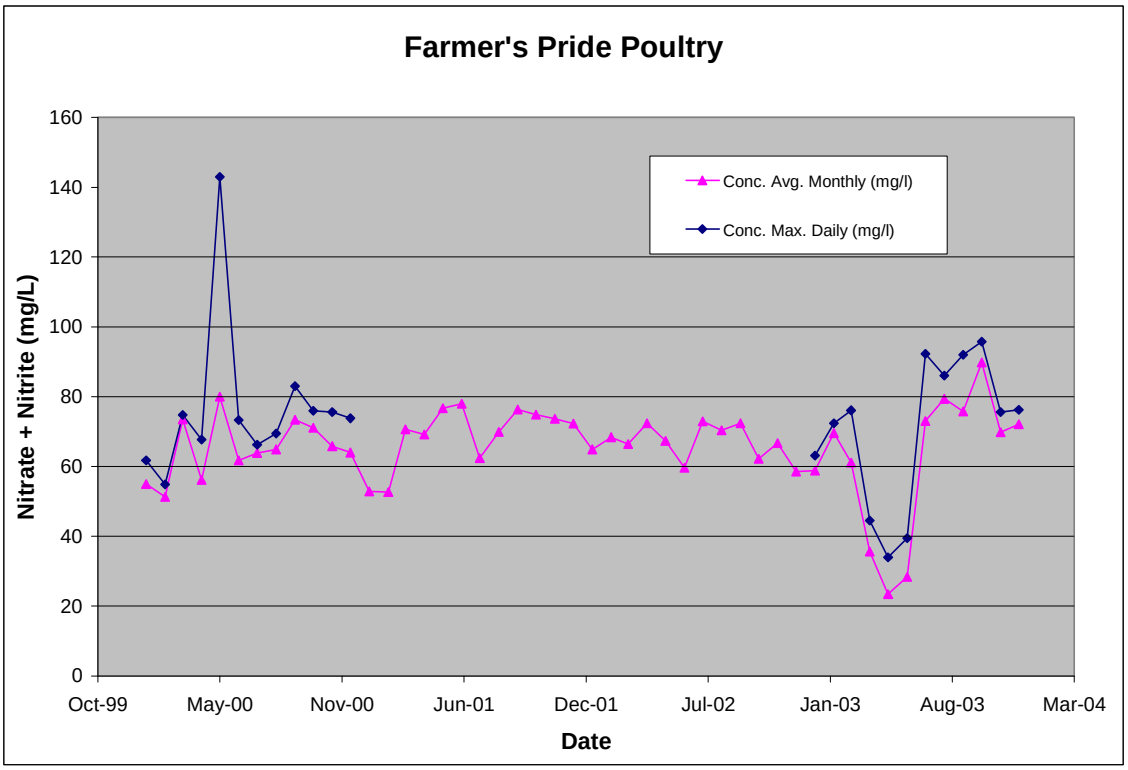


Figure 2-9: Permitted Facilities - Total Phosphorus Concentrations

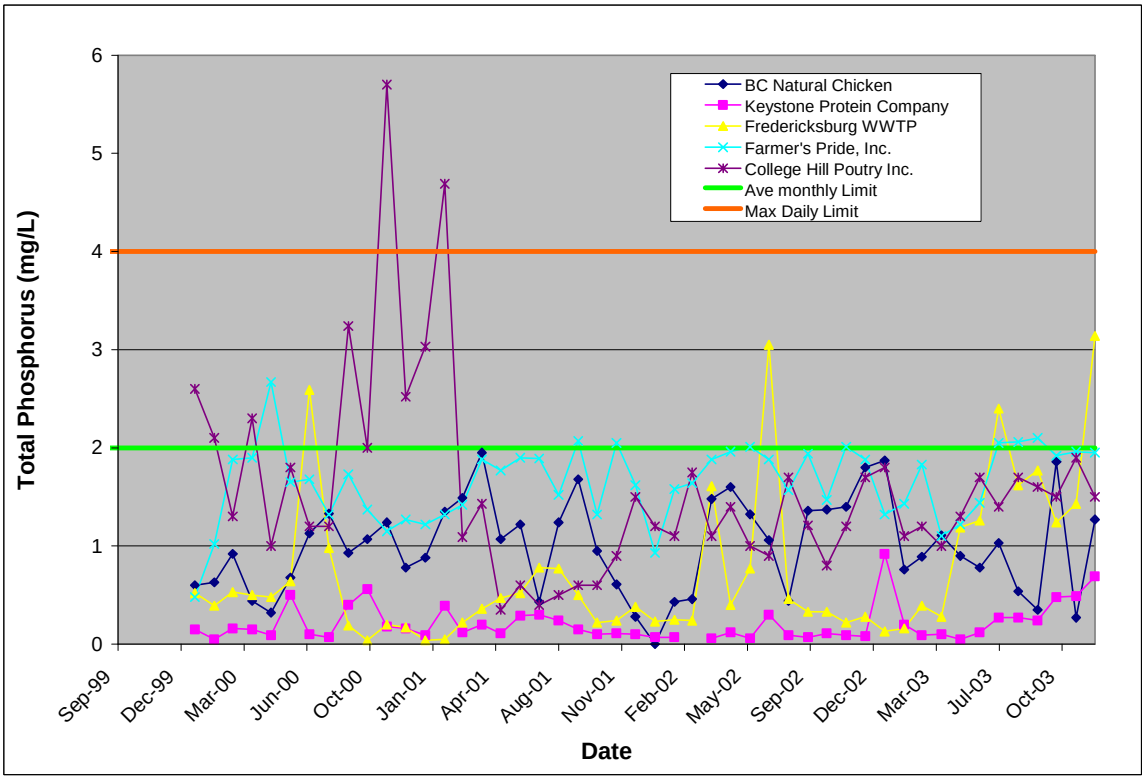


Figure 2-10: Permitted Facilities - Carbonaceous Biochemical Oxygen Demand

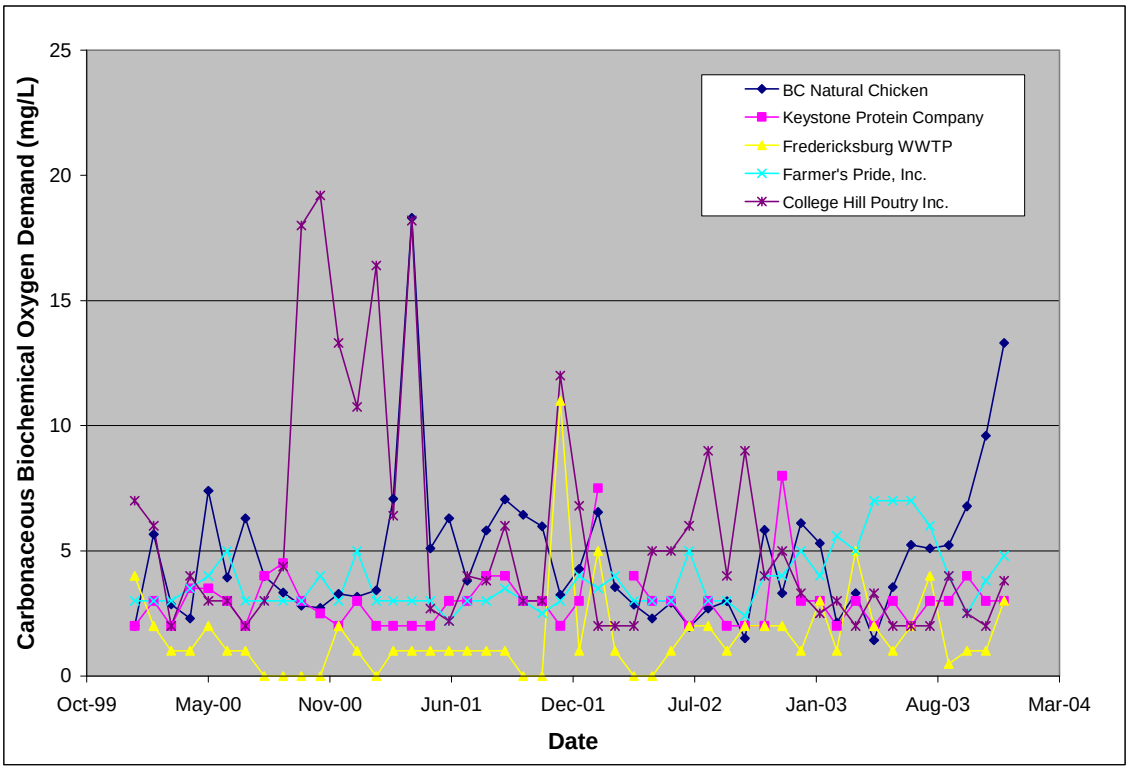


Figure 2-11: Permitted Facilities - Dissolved Oxygen Concentrations

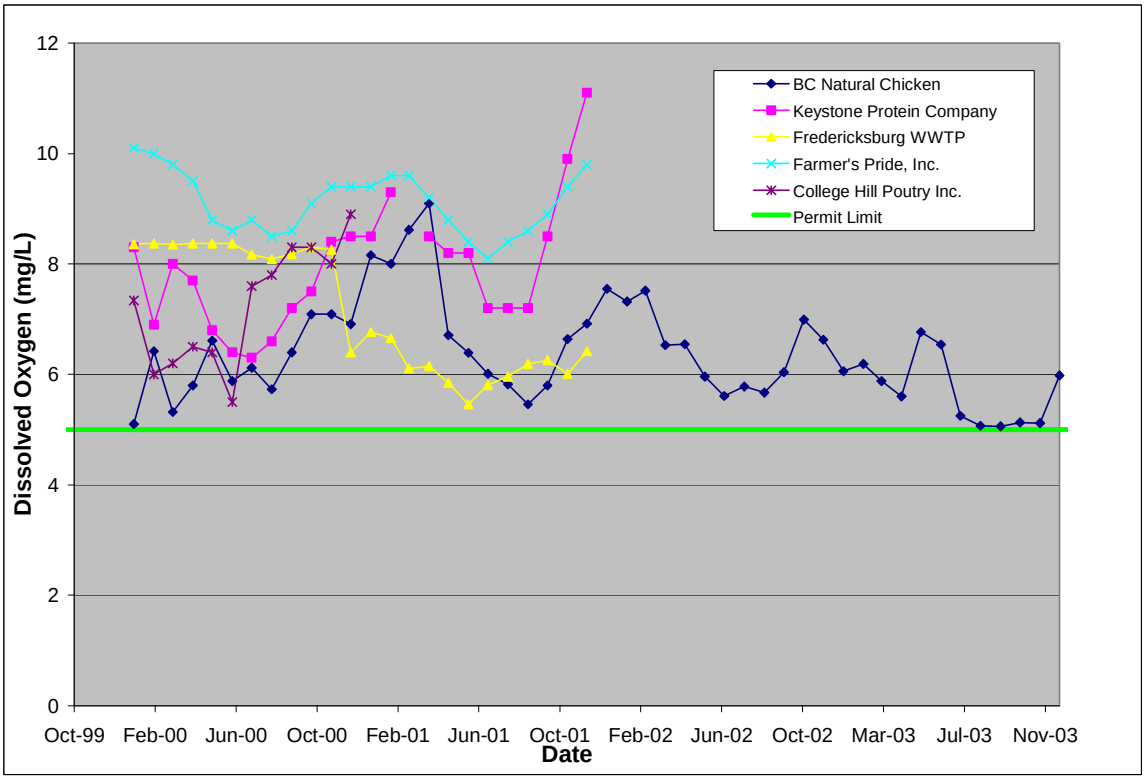


Figure 2-12: Permitted Facilities - pH

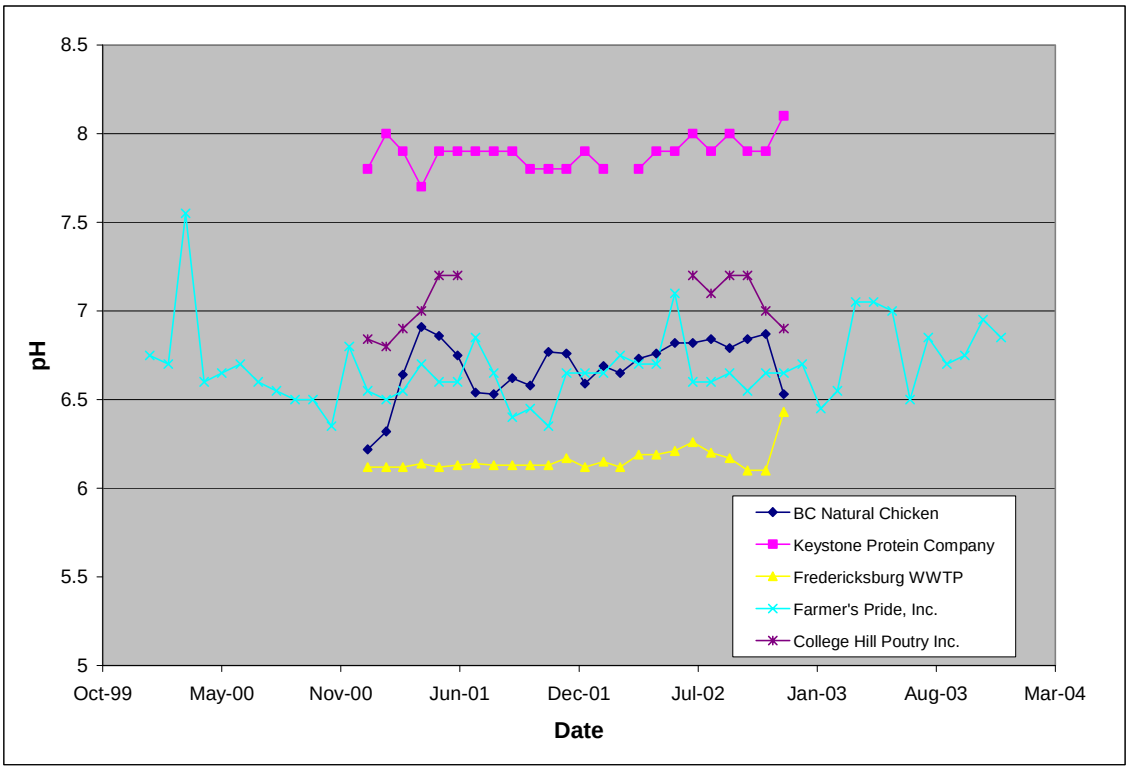
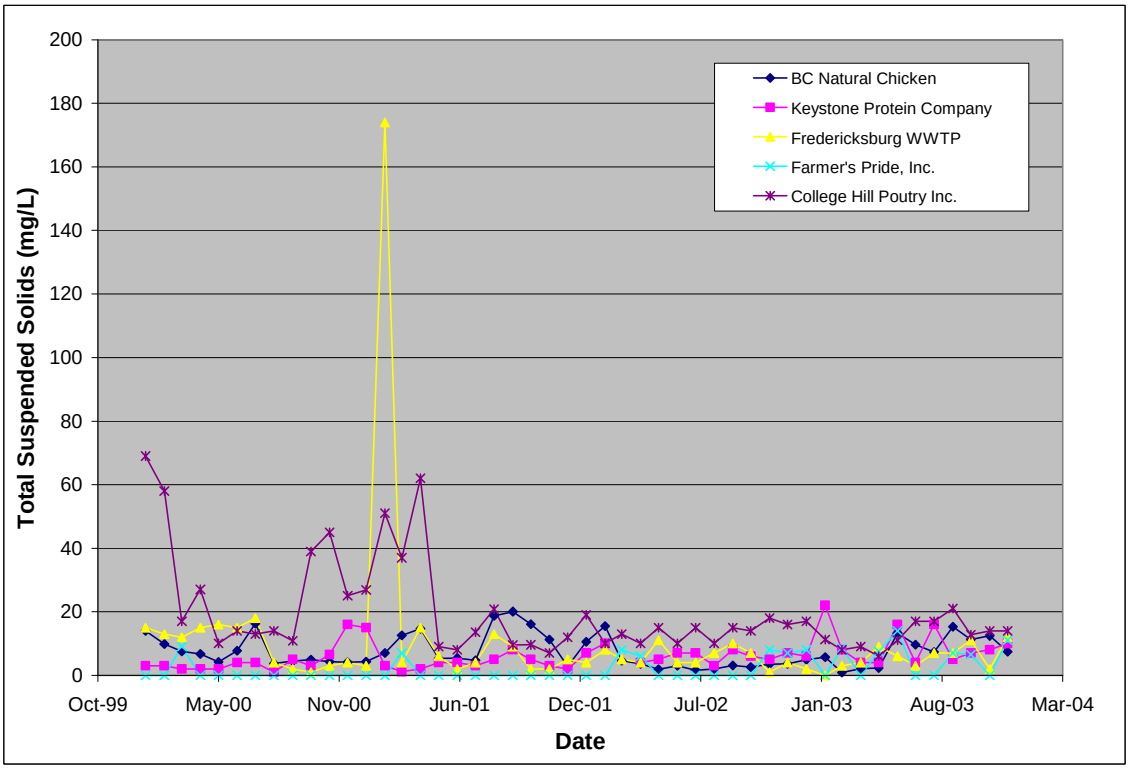


Figure 2-13: Permitted Facilities – Total Suspended Solids



2.3.4 Groundwater Monitoring

Groundwater monitoring data for the Deep-Beach-Elizabeth Run watershed were obtained from 9 wells associated with the several of the permitted facilities in the watershed. Data were available from 1998 to 2003. Three wells were sampled by the Fredericksburg Water Authority, and two wells each were associated with BC Natural Chicken, College Hill Poultry, and Farmer's Pride Poultry. The locations of the wells are depicted in Figure 2-14. Because the monitoring wells associated with each facility are located in close proximity to each other, wells for each of the individual facilities are discussed and presented as a group.

Groundwater nitrate concentrations in wells associated with four of the permitted facilities are presented in Figure 2-15. No violations of Pennsylvania's 10 mg/L source water quality standard for nitrate were observed at wells associated with College Hill Poultry, Farmer's Pride Poultry, or the Fredericksburg Water Authority. Five violations of the source water quality standard for nitrate occurred at wells associated with the BC Natural Chicken facility. These violations occurred in January 1999, October of 2001 and 2002, and February and June of 2003. Additionally, observed nitrate concentrations in the BC Natural Chicken wells approached the 10 mg/L source water quality standard on several other occasions. No violations of Pennsylvania's water quality standards occurred for any other measured parameter at these groundwater monitoring wells.

Figure 2-14: Location of Groundwater Monitoring Wells

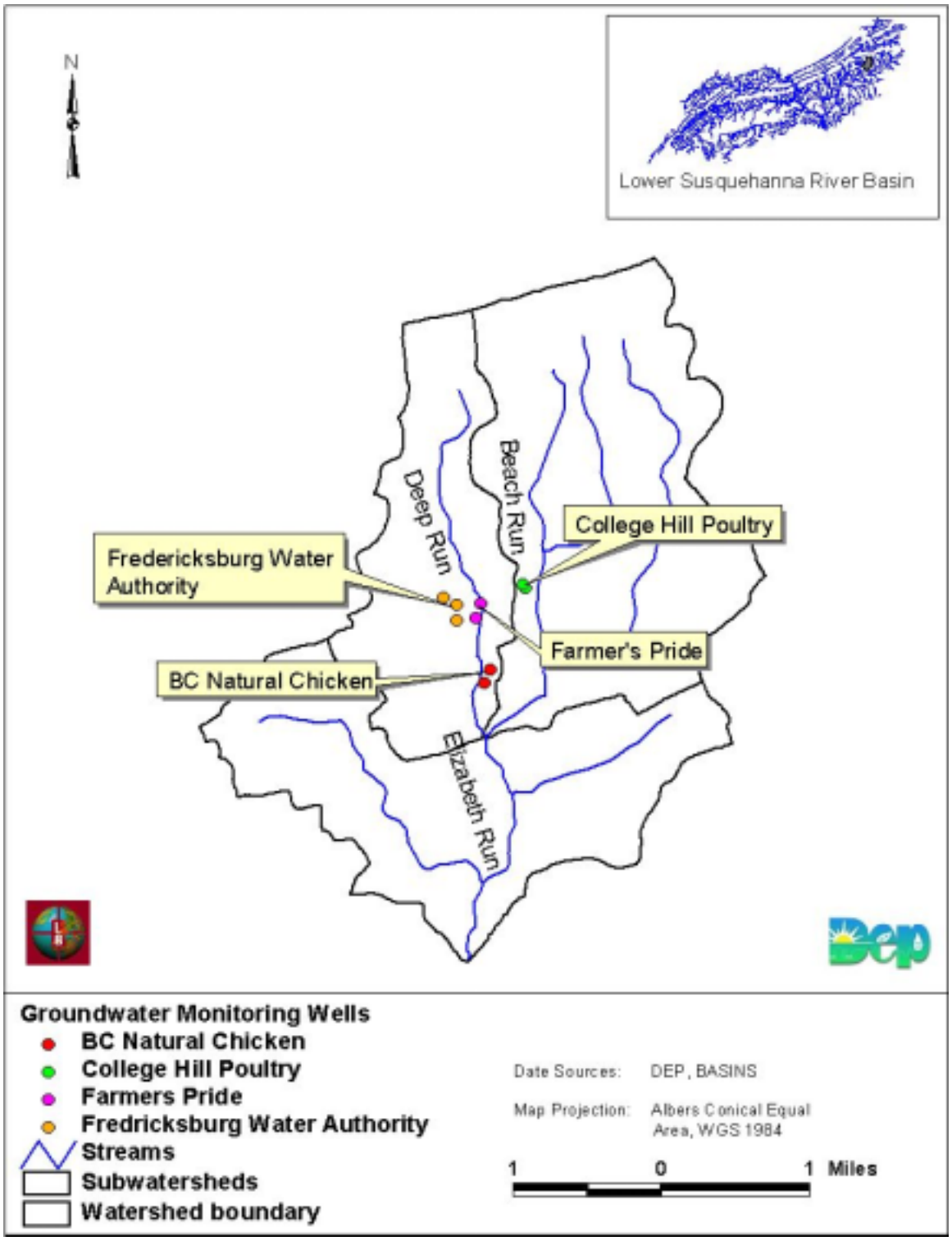
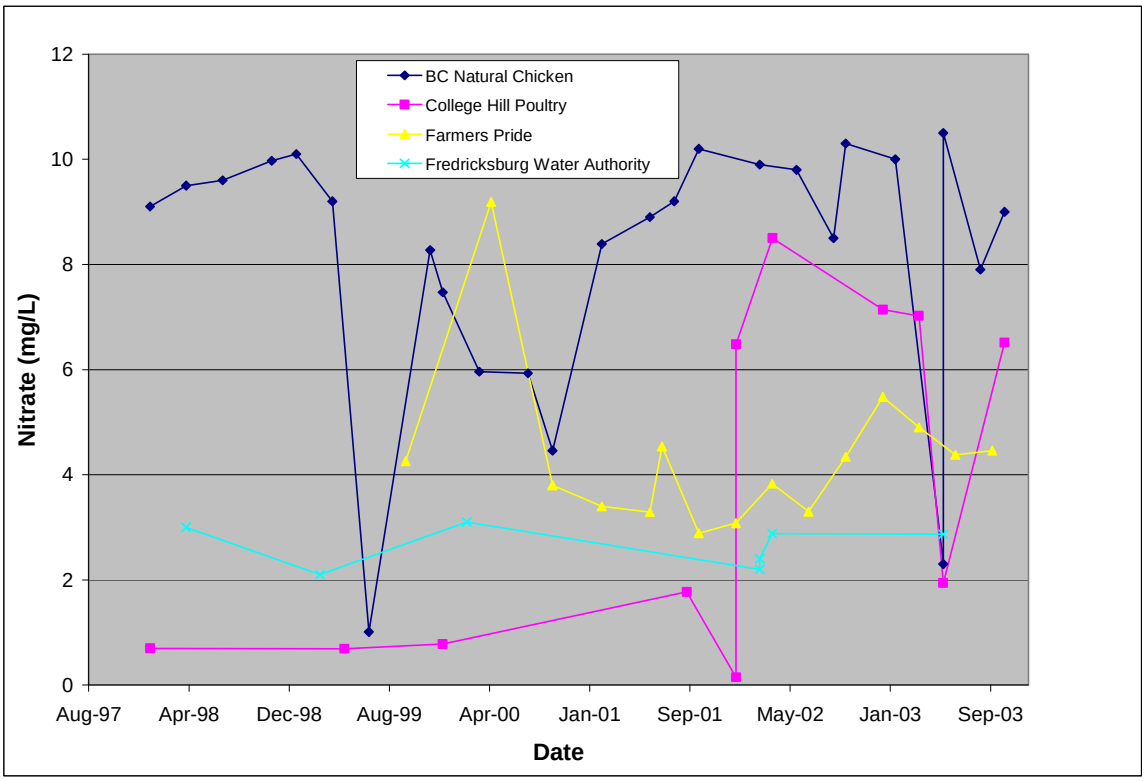


Figure 2-15: Groundwater Nitrate Concentrations in the Deep-Beach-Elizabeth Run Watershed



2.4 Nutrient Sources Assessment

Nutrients can enter surface waters from several sources and via several pathways. Permitted point sources, such as those discussed above, can discharge nutrients directly into a stream, or nutrients from these sources may leech into the groundwater. Nutrients can also leech into the groundwater from septic systems. Livestock grazing in pasture areas of the watershed may excrete nutrients directly into the stream, or nutrients may leech into the groundwater or be washed off into the stream during precipitation events. In highly agricultural areas such as the Deep-Beach-Elizabeth Run watershed, the spreading of manure from confined livestock or human biosolids is a common practice. Nutrients from these sources may enter the surface water from washoff during precipitation events, or via subsurface flow. Permitted point sources were discussed earlier in this section. Other potential nutrient sources such as septic systems, livestock, land application of manure, and land application of biosolids are discussed below.

2.4.1 Septic Systems

Information on the number of septic systems in the watershed was obtained from data provided as part of the AVGWLF model developed for Pennsylvania. The number of septic systems present in the watershed was determined using a statewide U.S. census tract GIS layer that reflected conditions from the 1990 population census. To determine the percentage of households and the number of people in the watershed on septic systems versus those connected to sewers, watershed population estimates were also calculated from the census data.

Three census tracks fell within the boundaries of the Deep-Beach-Elizabeth Run watershed. Septic system estimates were developed by calculating the percentage of each census track that fell within the watershed, then multiplying this percentage by the number of septic systems in the whole census track, and summing the results. From this approach it was estimated that there were 350 septic systems and 138 connections to sewers in the watershed. Using the same approach, the population of the watershed was estimated at 1,384 people, and the number of households in the watershed was estimated at 488. The average number of people per household in the Deep-Beach-Elizabeth Run watershed was estimated to be 2.84. By dividing the number of septic systems by the total number of households, it was determined that approximately 72 percent of households in the Deep-Beach-Elizabeth Run watershed are on septic systems, and 28 percent are connected to sewers. Of the 1,384 people in the watershed, approximately 993 are on septic systems and approximately 391 are connected to sewers. Table 2-10 summarizes the septic systems and population estimates for the Deep-Beach-Elizabeth Run watershed. Table 2-11 presents population and septic systems estimates for Deep Run, Beach Run, and Elizabeth Run individually.

Table 2-10: Septic Systems and Population Estimates for the Deep-Beach-Elizabeth Run Watershed

Waste Disposal Method	Number of Households	Percent of Households	Watershed Population
Septic System	350	72	993
Sewer	138	28	391
Total	488	100	1,384

Table 2-11: Septic Systems and Population Estimates for Deep Run, Beach Run, and Elizabeth Run

Septic Systems and Population Estimates	Number in Deep Run Watershed	Number in Beach Run Watershed	Number in Elizabeth Run Watershed
Septic Systems	77	145	128
Sewer	25	47	66
Watershed Population	275	518	591

2.4.2 Livestock

An inventory of the livestock residing in the Deep-Beach Elizabeth Run watershed was conducted using data obtained for Lebanon County from the Pennsylvania Agricultural Statistics Service. Estimates were calculated by dividing the land area of the Deep-Beach-Elizabeth Run watershed by the land area of Lebanon County, then multiplying this percentage by the county inventory for each reported type of livestock. The Deep-Beach-Elizabeth Run watershed makes up approximately 2.7 percent of the land area in Lebanon County. The data indicate that beef cattle, diary cows, chickens, hogs, sheep and lambs are present in the Deep-Beach-Elizabeth Run watershed. Estimates were generated using the most recent inventory data; chickens, hogs, and sheep and lambs were last inventoried in 2002, and beef cattle and diary cows were last inventoried in 2003. Estimates developed using inventory data averaged from 1999 to 2003 were very similar to those generated using the most recent inventory data, indicating that the most

recent (2002-2003) data were representative of typical livestock densities in the Deep-Beach-Elizabeth Run watershed. Table 2-12 summarizes the livestock inventory in the watershed. Table 2-13 presents the number of livestock present in the Deep Run, Beach Run, and Elizabeth Run watersheds individually.

Table 2-12: Deep-Beach-Elizabeth Run Watershed Livestock Inventory

Livestock Type	Total Number of Animals
Beef Cattle	809
Dairy Cows	536
Chickens	69,806
Hogs	2,626
Sheep and Lambs	34

Source: Pennsylvania Agricultural Statistics Service

Table 2-13: Number of Livestock in Deep Run, Beach Run, and Elizabeth Run

Livestock Type	Number in Deep Run Watershed	Number in Beach Run Watershed	Number in Elizabeth Run Watershed
Beef Cattle	185	370	254
Dairy Cows	120	240	176
Chickens	14,904	29,808	25,094
Hogs	750	1,500	376
Sheep and Lambs	9	17	8

2.4.3 Land Application of Manure

Land application of the manure that livestock produce while in confinement is a typical agricultural practice. Information on application of manure produced by the poultry facilities in the watershed was obtained from the DEP Southcentral Regional office. Farmer's Pride Poultry disposes of manure waste at three farm sites. In 2003, a total of 39.6 tons of dry solids (476,000 gallons) of manure from the Farmer's Pride plant were applied on 42.5 acres on the Brown-Bieber farm site. A total of 67 tons of dry solids (706,000 gallons) from the plant were applied to 67.2 acres on the Edris farm site during this time period, and a total of 45.1 tons of dry solids (460,000 gallons) from the plant were applied to 25.9 acres on the Koons farm site. From examination of USGS 7.5 minute quadrangle maps, it was determined that the Koons farm site is located entirely within the Deep-Beach-Elizabeth Run watershed, and that approximately 50 percent of the other two farm sites are also located within the watershed. Therefore, it was calculated that approximately 98.4 tons of dry solids (1,501,000 gallons) of manure from Farmer's Pride Poultry were spread in the Deep-Beach-Elizabeth Run watershed in 2003.

BC Natural Chicken disposes of manure waste at five farm sites. From examination of the maps provided and USGS 7.5 minute quadrangle maps, it was determined that two of these farm sites, the Detweiler Alph farm and the Richard Light farm, are located in the Deep-Beach-Elizabeth Run watershed. In 2002, 63.8 tons of dry solids (404,800 gallons) from the BC Natural Chicken Plant were applied to 90 acres on the Detweiler Alph farm, and 198.2 tons of dry solids (1,311,000 gallons) were applied to 130 acres on the Richard Light farm. In 2003, 49.3 tons of dry solids (239,200 gallons) from the BC Natural Chicken Plant were applied to 90 acres on the Detweiler Alph farm, and 137.1 tons of dry solids (1,163,800 gallons) were applied to 130 acres on the Richard Light farm. Using the most recent data, it appears that approximately 186.4 tons of dry solids (1,403,000 gallons) of manure from BC Natural Chicken were spread in the Deep-Beach-Elizabeth Run watershed in 2003. Based on the available data, there does not appear to be any additional spreading of manure in the Deep-Beach-Elizabeth Run watershed.

2.4.4 Land Application of Human Biosolids

Non-point sources of nutrients can be associated with the spreading of human biosolids. There is no reported land application of biosolids in the Deep-Beach-Elizabeth Run watershed.

2.5 Best Management Practices

Best management practices (BMPs) are practices that help reduce pollutant loadings and other impairments to streams. The DEP Southcentral Regional office indicated that very few BMPs have been implemented in the Deep-Beach-Elizabeth Run watershed, and that BMPs did not have a significant impact in the Deep-Beach-Elizabeth Run watershed. Therefore, BMPs were not considered in this TMDL.

3.0 Nutrient Loading Determination

This section describes the modeling approach used to develop nutrient TMDLs for Deep Run, Beach Run, and Elizabeth Run. The primary focus is on the model description and setup, model calibration, nutrient endpoint identification, and the existing nutrient load present in Deep Run, Beach Run, and Elizabeth Run.

3.1 Technical Approach for Estimating Nutrient Loads

Nutrient loads were determined using the Arcview Generalized Watershed Loading Functions (AVGWLF) model, and the QUAL2K stream water quality model. Non-point sources loads for Deep Run, Beach Run, and Elizabeth Run were calculated using AVGWLF. Nutrient loads from groundwater were calculated using AVGWLF and groundwater monitoring data. Annual point source loadings were computed based on mean discharge loading rates for nitrogen and phosphorus obtained from DMR data from the permitted facilities. After these loads were determined, the QUAL2K model was used to investigate the linkage between the identified nutrient loads and the instream response of Deep Run, Beach Run, and Elizabeth Run.

3.1.1 AVGWLF Model Description

For the purpose of TMDL development, annual nutrient loadings from land sources, septic systems, and groundwater were determined using the ArcView Generalized Watershed Loading Functions (AVGWLF) model. AVGWLF was developed by the Environmental Resources Research Institute of the Pennsylvania State University (Evans et al., 2001), and facilitates the use of the Generalized Watershed Loading Function (GWLF) model developed by Haith and Shoemaker (1987) via a GIS software interface.

GWLF is a time variable simulation model that simulates hydrology, sediment and nutrient loadings on a watershed basis. Observed daily precipitation data is required in GWLF as the basis for water budget calculations. Surface runoff, evapotranspiration and groundwater flows are calculated based on user specified parameters. Stream flow is the sum of surface runoff and groundwater discharge. Surface runoff is computed using the Soil Conservation Service Curve Number Equation. Curve numbers are a function of

soils and land use type. Evapotranspiration is computed based on the method described by Hamon (1961) and is dependent upon temperature, daylight hours, saturated water vapor pressure, and a cover coefficient. Groundwater discharge to the stream is described by a lumped parameter watershed water balance for unsaturated and shallow saturated water zones. Infiltration to the unsaturated zone occurs when precipitation exceeds surface runoff and evapotranspiration. Percolation to the shallow saturated zone occurs when the unsaturated zone capacity is exceeded. The shallow saturated zone is modeled as a linear reservoir to calculate groundwater discharge. In addition, the model allows for seepage to a deep saturated zone.

Nutrient loading is a function of concentrations of dissolved nutrients in the groundwater and runoff from land sources areas, as well as particulate nutrients associated with sediments, and nutrients originating from septic systems. Groundwater nutrient concentrations are computed using an AVGWLF dataset derived from the U.S. Geological Survey's National Water Quality Assessment Program (NAWQA) studies. However, in this study groundwater nutrient concentrations calculated in AVGWLF were adjusted based on groundwater monitoring data collected in the watershed. Particulate nutrient levels are computed using a dataset derived from Pennsylvania soil test data compiled by the Pennsylvania State University. Nutrient loadings from surface runoff are determined based on land use and soils distributions, as well as groundwater and soil nutrient levels. Particulate nutrients associated with sediment are calculated by applying a nutrient loading coefficient to the computed sediment loads. Septic systems in the watershed are estimated using U.S. Census data.

3.1.2 Point Source Load

There are five point source facilities present in the Deep-Beach-Elizabeth Run watershed, as shown in Table 3-1. For the purpose of TMDL development, the annual point source loadings were computed based on mean discharge rates for ammonia and total phosphorus obtained from DMR data from the permitted facilities. Only one of the five facilities, Farmer's Pride Poultry, monitors effluent nitrate concentrations. The instream data and groundwater well data indicated that there is a significant nitrate load to Deep Run, Beach Run, and Elizabeth Run in the area surrounding the permitted facilities.

Therefore, to establish a conservative estimate of total nitrate loading from point sources, it was assumed that all five facilities were discharging effluent nitrate in concentrations similar to those observed at the Farmer's Pride facility.

Table 3-1: Point Sources in Deep Run, Beach Run, and Elizabeth Run

Facility Name	Permit No.	Average Monthly Flow (m3/s)	Average Monthly Ammonia (mg/L)	Average** Monthly Nitrate (mg/L)	Average Monthly Total Phosphorus (mg/L)
Keystone Protein Company	PA0080829	0.003	0.14	65.6	0.2
BC Natural Chicken	PA0024228	0.018	1.83	65.6	0.9
Farmer's Pride Poultry	PA0035157	0.022	1.93	65.6	1.7
College Hill Poultry	PA0008010	0.005	3.66	65.6	1.6
Fredericksburg STP	PA0080705	0.003	2.24	65.6	1.9

**: Effluent nitrate concentrations from the Farmer's Pride facility was used to estimate nitrate concentrations at the other facilities.

3.1.3 QUAL2K Model Description

The QUAL2K model was used to investigate the linkage between non-point source loads generated for Deep Run, Beach Run, and Elizabeth Run in AVGWLF, loading from point sources, and instream water quality conditions. QUAL2K is a one-dimensional river and stream water quality model that is capable of simulating nutrient loading, as well as the in-stream responses to such loadings. The QUAL2K model simulates non-uniform, steady flow, and simulates temperature, heat, and water quality kinetics on a diurnal time scale. A mass-balance approach is used to model nutrients in each reach. The model represents the stream mainstem, but tributaries can also be included into the model as point sources contributing a specific load. In the case of Deep-Beach-Elizabeth Run, non-point and point source nutrient loads from Beach Run modeled using AVGWLF were represented as discreet loads input to the stream mainstem, which was defined as the headwaters of Deep Run to the mouth of Elizabeth Run.

3.2 AVGWLF Model Setup and Calibration

3.2.1 AVGWLF Model Development

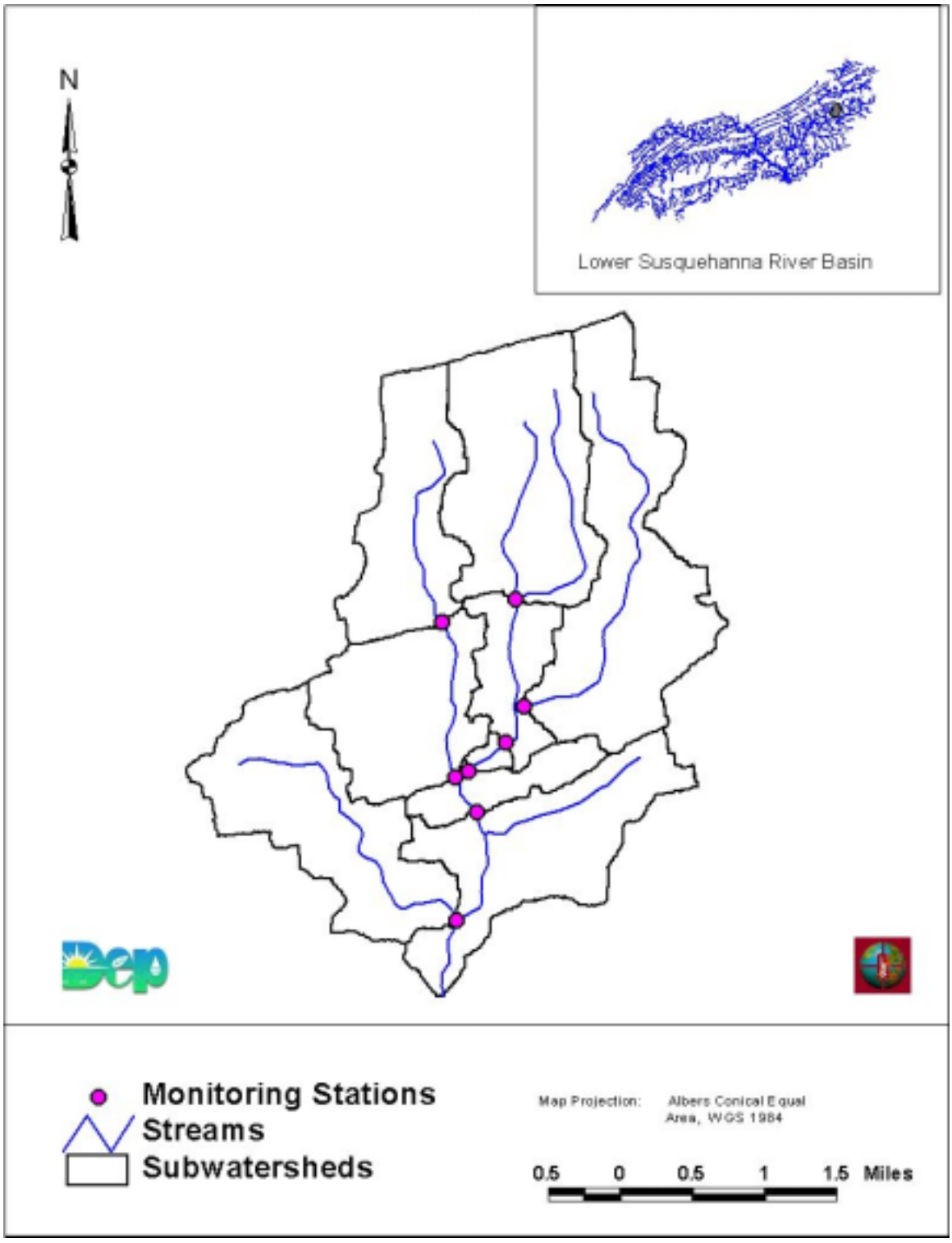
AVGWLF model simulations were performed for the period of 1988 to 1998. The 10 year simulation period accounts for both seasonal and annual variations in hydrology and pollutant loading. Input parameters were computed from statewide datasets for Pennsylvania that were included with the AVGWLF model, as well as additional datasets such as the NLCD land use dataset. A complete list of the datasets used in the AVGWLF model is presented in Table 3-2.

The Deep-Beach-Elizabeth Run watershed was delineated into 9 smaller subwatersheds to represent the watershed characteristics and improve the loading estimates from different source areas. The subwatershed delineation was based on topographic characteristics, and was created using a 10-meter Digital Elevation Model (DEM), stream reaches obtained from the RF3 dataset, and delineation tools from BASINS software. Subwatersheds were delineated at the 9 water quality monitoring stations sampled by DEP (Figure 2-3). A map showing the delineated subwatersheds for Deep-Beach-Elizabeth Run is presented in Figure 3-1.

Table 3-2: Description of Datasets Used to Generate Model Input Parameters

AVGWLF Dataset	Description
Animal densities	Mean livestock densities in Pennsylvania
Census data	Dataset providing U.S. Census data, including information on septic systems used to compute nutrient loading.
County	Contains county soils information, including conservation practices and input values for the Universal Soil Loss Equation (USLE).
Digital elevation model	100 meter DEM used to characterize topography.
Groundwater nitrogen	Grid of background nitrogen concentrations present in groundwater.
Land use	National Land Cover Data (NLCD).
Point sources	Coverage of permitted point source dischargers. Updated based on more detailed point source information provided by DEP.
Physiographic providences	Physiographic providences in Pennsylvania.
Roads	Major roads in watershed.
Soils	Generalized soils from the STATSGO database.
Soil phosphorus	Grid of phosphorus loads generated from soil sample data.
Streams	1:24,000 stream coverage for Pennsylvania.
Surface geology	Dataset of surface geology types.
Weather	Long-term weather data for 80 stations in Pennsylvania

Figure 3-1: Subwatershed delineation for Deep-Beach-Elizabeth Run



3.2.2 AVGWLF Model Input Parameters

The AVGWLF model requires specification of input parameters relating to climate, hydrology, erosion, nutrient yield, and sediment yield. These parameters are automatically computed in AVGWLF using the input datasets described above

Runoff curve numbers and USLE erosion factors were specified by AVGWLF as an average value for a given source area. The land use types present in Deep Run, Beach Run, and Elizabeth Run were used to define model source areas. Although the AVGWLF model provides land use data from the Multi-Resolution Land Characteristic (MRLC) dataset, the land use distributions in the Deep-Beach-Elizabeth Run and Hassen Creek watersheds were updated based on the more recent NLCD dataset. Nutrient loading from open water and wetlands is not typically significant, so these land uses were not specified as source areas of nutrients in the AVGWLF model.

Table 3-3: Land Use Distributions Used in AVGWLF Model

Land Use Category	Land Use Type	% of Deep Run Watershed	% of Beach Run Watershed	% of Elizabeth Run Watershed
Water/Wetlands	Open Water	0.3	0.4	0.2
	Woody Wetlands	0.0	0.1	0.4
	Emergent Herbaceous Wetlands	0.3	0.5	0.4
Developed	Low Intensity Residential	3.2	2.6	0.2
	High Intensity Residential	1.0	0.4	Not present
	Commercial/Industrial	3.0	3.2	0.3
Agriculture	Pasture/Hay	62.2	54.2	76.6
	Row Crop	13.3	18.2	14.9
Forest	Deciduous Forest	12.1	18.1	4.9
	Evergreen Forest	1.9	1.0	1.8
	Mixed Forest	2.7	1.3	1.2
Total		**100**	**100**	**100**

The GWLF model was originally developed as a planning tool for estimating nutrient and sediment loadings on a watershed basis. Designers of the model intended it to be implemented without calibration. Precipitation data were computed in AVGWLF using data from three area weather stations. Area-weighted evapotranspiration cover

coefficients were developed for each model source area in the AVGWLF model based on values suggested by Haith et al. (1992).

The STATSGO soils dataset was used by AVGWLF to examine soil properties for each model source area. USLE factors for soil erodibility (K), length-slope (LS), cover and management (C), and supporting practice (P) were derived from multiple data sources contained in the AVGWLF model, such as the STATSGO soil database, digital elevation models, and county-specific information. The sediment delivery ratio was applied directly by AVGWLF, and was based on the sizes of the watersheds.

Nutrient loads were computed based on land use, geology, soils, groundwater nitrogen, and soil phosphorus datasets contained in the AVGWLF model, as well as groundwater monitoring data collected in the watershed. Loads were determined by applying a dissolved coefficient to surface runoff calculations, and by applying a sediment coefficient to the load from each agricultural source area. Nutrient loads originating from urban sources were modeled in AVGWLF as solid-phase, using an exponential accumulation and washoff function. Groundwater contributions to stream nutrient loads are calculated using a dissolved phosphorus coefficient for shallow groundwater.

3.3 Existing Nutrient Loading

3.3.1 Non-point Source Nutrient Loads

The existing nutrient loads for nitrogen and phosphorus were calculated by summing nutrient loads modeled for each subwatershed in Deep Run, Beach Run, and Elizabeth Run. Figure 3-4 shows the non-point source nitrogen and phosphorus loads for Deep Run. Figure 3-5 shows the non-point source nitrogen and phosphorus loads for Beach Run. The non-point source nitrogen and phosphorus loads for Elizabeth Run are presented in Figure 3-6. Non-point source nutrient loads were distributed to various land sources based on the land use distributions in the watersheds.

Table 3-4: Non-point Source Nitrogen and Phosphorus Loads (lbs/year) for Deep Run

Source	Land Use Type	Deep Run Nitrogen Load	Deep Run Phosphorus Load
Land Sources	Low Intensity Residential	0.1	0.02
	High Intensity Residential	0.03	0.0
	Commercial/Industrial	0.1	0.02
	Pasture/Hay	1497.9	312.2
	Row Crop	846.9	303.4
	Deciduous Forest	87.5	23.1
	Evergreen Forest	2.5	0.1
	Mixed Forest	3.7	0.2
Septic Systems	-	693.3	0
Groundwater	-	16003.9	2127.4
Total		19135.93	2766.44

Table 3-5: Non-point Source Nitrogen and Phosphorus Loads (lbs/year) for Beach Run

Source	Land Use Type	Beach Run Nitrogen Load	Beach Run Phosphorus Load
Land Sources	Low Intensity Residential	0.3	0.0
	High Intensity Residential	0.0	0.0
	Commercial/Industrial	0.3	0.0
	Pasture/Hay	3095.2	446.5
	Row Crop	3470.2	896.7
	Deciduous Forest	260.8	93.7
	Evergreen Forest	1.1	0.1
	Mixed Forest	4.0	0.2
Septic Systems	-	1331.7	1.9
Groundwater	-	61334.3	2289.6
Total		69497.9	3728.8

Table 3-6: Non-point Source Nitrogen and Phosphorus Loads (lbs/year) for Elizabeth Run

Source	Land Use Type	Elizabeth Run Nitrogen Load	Elizabeth Run Phosphorus Load
Land Sources	Low Intensity Residential	0.0	0.0
	High Intensity Residential	Not present	Not present
	Commercial/Industrial	0.0	0.0
	Pasture/Hay	5308.9	695.9
	Row Crop	1997.9	274.5
	Deciduous Forest	8.4	0.4
	Evergreen Forest	1.2	0.2
	Mixed Forest	2.2	0.1
Septic Systems	-	1131.2	3.8
Groundwater	-	80566.8	619.0
Total		89016.6	1593.8

3.3.2 Point Source Nutrient Loads

Nutrient loads from the five point source facilities are shown in Table 3-7. For the purpose of TMDL development, the annual existing point source loadings were computed based on mean discharge loading rates for ammonia and total phosphorus obtained from DMR data from the permitted facilities. Nitrate loadings for the five facilities were based on mean nitrate concentrations from the DMR data for Farmer's Pride poultry, because there was no available data on nitrate discharge rates for the other four facilities. This approach resulted in a conservative estimate of point source loadings of nitrogen.

Table 3-7: Point Sources in Deep Run, Beach Run, and Elizabeth Run

Facility Name	Permit No.	Receiving Stream	Average** Nitrogen Loading (lbs/year)	Average Phosphorus Loading (lbs/year)
Keystone Protein Company	PA0080829	Beach Run	50062.2	153.0
BC Natural Chicken	PA0024228	Deep Run	123238.0	1641.6
Farmer's Pride Poultry	PA0035157	Deep Run	185131.2	4658.4
College Hill Poultry	PA0008010	Beach Run	31645.7	732.4
Fredericksburg STP	PA0080705	Deep Run	30996.8	416.3

**: Effluent nitrate concentrations from the Farmer's Pride facility was used to estimate nitrate concentrations at the other facilities.

3.3.3 Existing Nutrient Loads – All Sources

Average annual nutrient loads from all sources for the Deep Run, Beach Run, and Elizabeth Run watersheds are summarized in Table 3-8, Table 3-9, and Table 3-10.

Table 3-8: Average Annual Source Nitrogen and Phosphorus Loads (lbs/year) for Deep Run

Source	Land Use Type	Deep Run Nitrogen Load	Deep Run Phosphorus Load
Land Sources	Low Intensity Residential	0.1	0.02
	High Intensity Residential	0.03	0.0
	Commercial/Industrial	0.1	0.02
	Pasture/Hay	1497.9	312.2
	Row Crop	846.9	303.4
	Deciduous Forest	87.5	23.1
	Evergreen Forest	2.5	0.1
	Mixed Forest	3.7	0.2
Septic Systems	-	693.3	0
Groundwater	-	16003.9	2127.4
Point Sources	-	339366.0	6716.3
Total		358501.9	10483.44

Table 3-9: Average Annual Source Nitrogen and Phosphorus Loads (lbs/year) for Beach Run

Source	Land Use Type	Beach Run Nitrogen Load	Beach Run Phosphorus Load
Land Sources	Low Intensity Residential	0.3	0.0
	High Intensity Residential	0.0	0.0
	Commercial/Industrial	0.3	0.0
	Pasture/Hay	3095.2	446.5
	Row Crop	3470.2	896.7
	Deciduous Forest	260.8	93.7
	Evergreen Forest	1.1	0.1
	Mixed Forest	4.0	0.2
Septic Systems	-	1331.7	1.9
Groundwater	-	61334.3	2289.6
Point Sources	-	81707.9	885.4
Total		151205.8	4614.1

Table 3-10: Average Annual Nitrogen and Phosphorus Loads (lbs/year) for Elizabeth Run

Source	Land Use Type	Elizabeth Run Nitrogen Load	Elizabeth Run Phosphorus Load
Land Sources	Low Intensity Residential	0.0	0.0
	High Intensity Residential	Not present	Not present
	Commercial/Industrial	0.0	0.0
	Pasture/Hay	5308.9	695.9
	Row Crop	1997.9	274.5
	Deciduous Forest	8.4	0.4
	Evergreen Forest	1.2	0.2
	Mixed Forest	2.2	0.1
Septic Systems	-	1131.2	3.8
Groundwater	-	80566.8	619.0
Point Sources	-	0.0	0.0
Total		89016.6	1593.8

3.4 QUAL2K Model Setup and Calibration

3.4.1 QUAL2K Model Development

The QUAL2K model was used to link the nutrient loads generated for Deep Run, Beach Run, and Elizabeth Run in AVGWLF and loading from point sources to instream water quality conditions. The QUAL2K model was used to simulate summer conditions under steady state flow conditions.

QUAL2K models were developed for both the watershed mainstem, defined as the headwaters of Deep Run to the mouth of Elizabeth Run, and the Beach Run watershed, defined as Beach Run from its headwaters to its mouth. Non-point and point source nutrient loads from Beach Run modeled using AVGWLF were represented as discreet loads input to the stream mainstem. Input headwater data for the QUAL2K models were based on observed instream water quality and flow data. Model reaches were defined as 0.25 km each; a total of 7 reaches were present in the Beach Run model, and a total of 19 reaches were present in the mainstem model. Channel dimensions for Deep Run, Beach Run, and Elizabeth Run were measured in the field. Air temperature, dew point temperature, and wind speed parameters were based on monthly average values for the southcentral region of Pennsylvania.

Permitted point sources and inflowing tributaries were treated as discreet inputs. Input parameters from permitted point sources were based on the available DMR data from the facilities. The modeled nutrient loads from the AVGWLF model were used as the input nutrient loads for inflowing tributaries in the QUAL2K model. Other input parameters for inflowing tributaries were obtained from observed water quality data. Nutrient loads modeled in AVGWLF for the stream mainstem were treated as diffuse sources in the QUAL2K model, and were equally distributed along the length of the modeled segment. Since Beach Run was modeled separately, output parameters from the Beach Run QUAL2K model were used as inputs to the mainstem model, representing Deep Run and Elizabeth Run.

3.4.2 QUAL2K Model Calibration

The QUAL2K model was calibrated based on diurnal dissolved oxygen data collected by DEP in May 2004, by comparing model results with observed data in order to provide guidance on parameter adjustment. The Beach Run and mainstem QUAL2K models were calibrated for dissolved oxygen by plotting modeled concentrations against the observed water quality data collected along the length of the modeled stream mainstem. Additionally, modeled dissolved oxygen concentrations were calibrated over the diurnal cycle to ensure that instream processes were properly represented throughout the day. The QUAL2K model dissolved oxygen calibration along the mainstem segment is presented in Figure 3-2. Deep Run extends from kilometer 4.6 to kilometer 2.8, where Deep Run confluences with Beach Run. Elizabeth Run extends from kilometer 2.8 to kilometer 0.0, the mouth of Elizabeth Run. Note that dissolved oxygen concentrations decrease slightly along the modeled segment between kilometer 2.5 and kilometer 3.0, below the outfalls of three of the permitted point source facilities and upstream of the Beach Run tributary. The mainstem QUAL2K model diurnal dissolved oxygen calibration is shown in Figure 3-3. The QUAL2K model dissolved oxygen calibration along the Beach Run segment is presented in Figure 3-4. The Beach Run QUAL2K model diurnal dissolved oxygen calibration is shown in Figure 3-5.

Figure 3-2: Dissolved Oxygen Calibration for the QUAL2K Mainstem Model

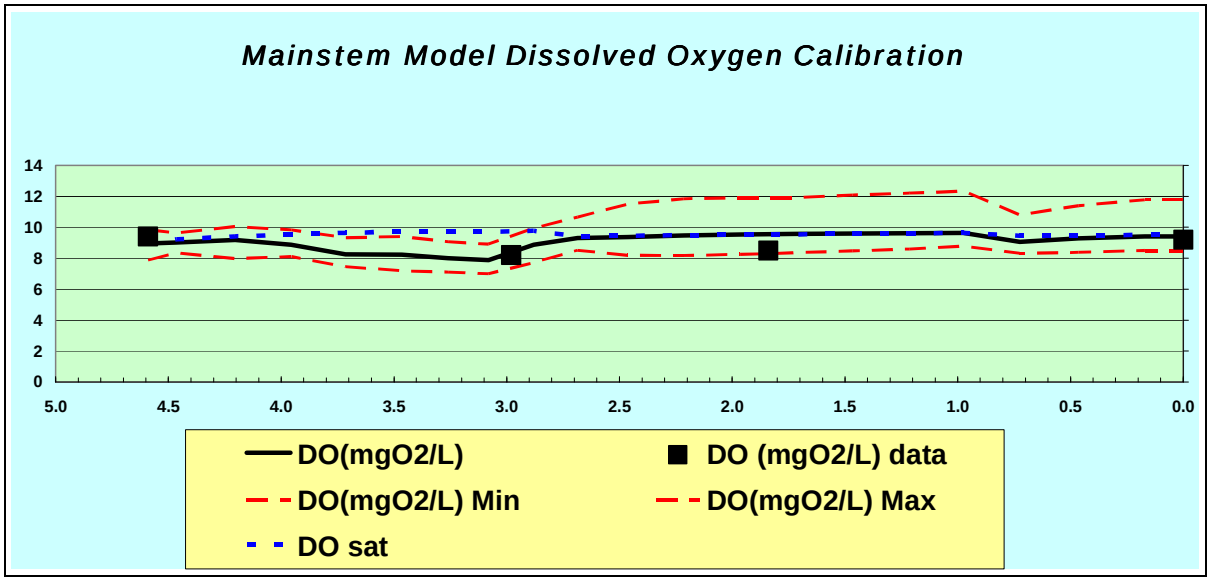


Figure 3-3: Diurnal Dissolved Oxygen Calibration for the QUAL2K Mainstem Model

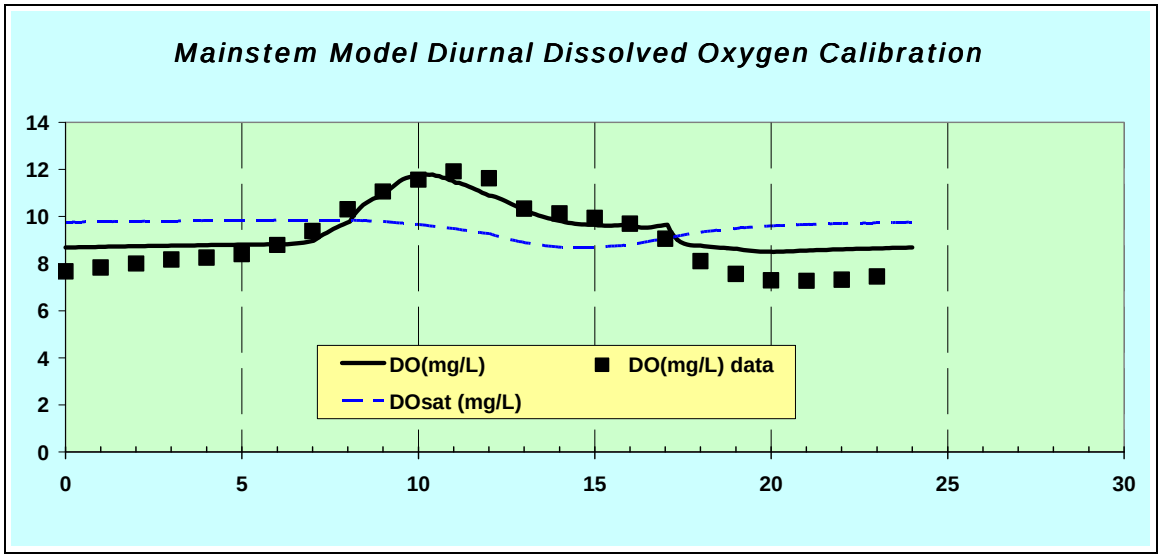


Figure 3-4: Dissolved Oxygen Calibration for the QUAL2K Beach Run Model

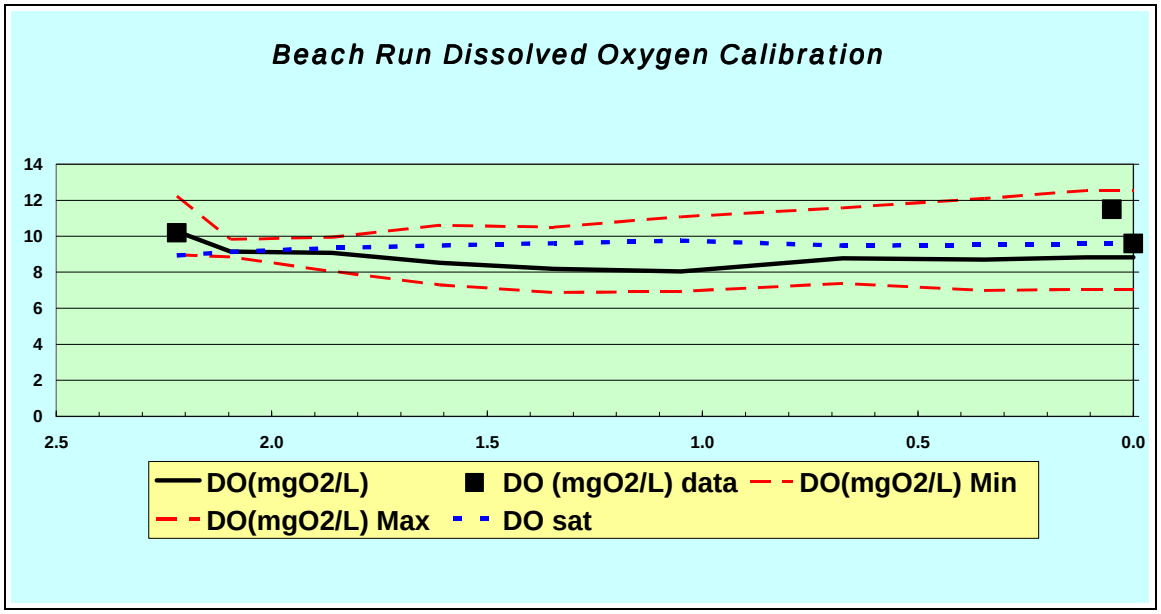
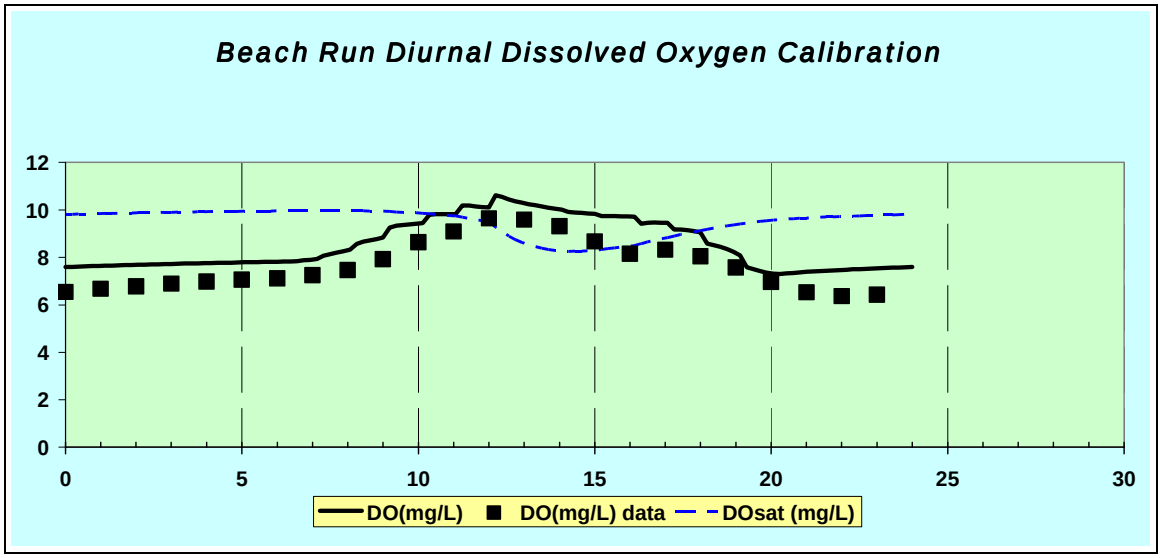


Figure 3-5: Diurnal Dissolved Oxygen Calibration for the QUAL2K Beach Run Model



Additionally, the QUAL2K models were calibrated to observed data for other parameters, such as nitrate, phosphorus, temperature, and stream flow in order to ensure that the QUAL2K models were accurately representing instream processes and observed water quality values for May. The mainstem QUAL2K model nitrate calibration is presented in Figure 3-6. The mainstem QUAL2K model ammonia calibration is presented in Figure 3-7. The mainstem QUAL2K model phosphorus calibration is presented in Figure 3-8. The mainstem QUAL2K model temperature calibration is presented in Figure 3-9. The stream flow calibration for the QUAL2K mainstem model is presented in Figure 3-10.

The next step in TMDL development for Deep Run, Beach Run, and Elizabeth Run was to establish the critical condition under which water quality violations resulting from the high nutrient loads is likely to occur, and to determine the necessary reductions that would not result in water quality violations. Evaluation of the critical condition and development of nutrient endpoints is presented in Section 4.0.

Figure 3-6: Nitrate Calibration for the QUAL2K Mainstem Model

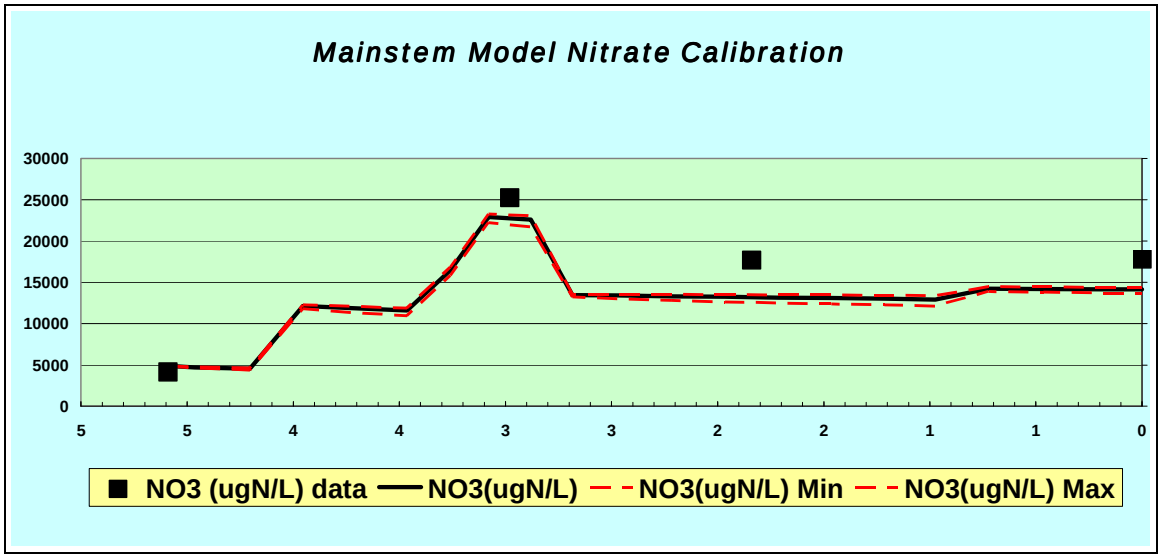


Figure 3-7: Ammonium Calibration for QUAL2K Mainstem Model

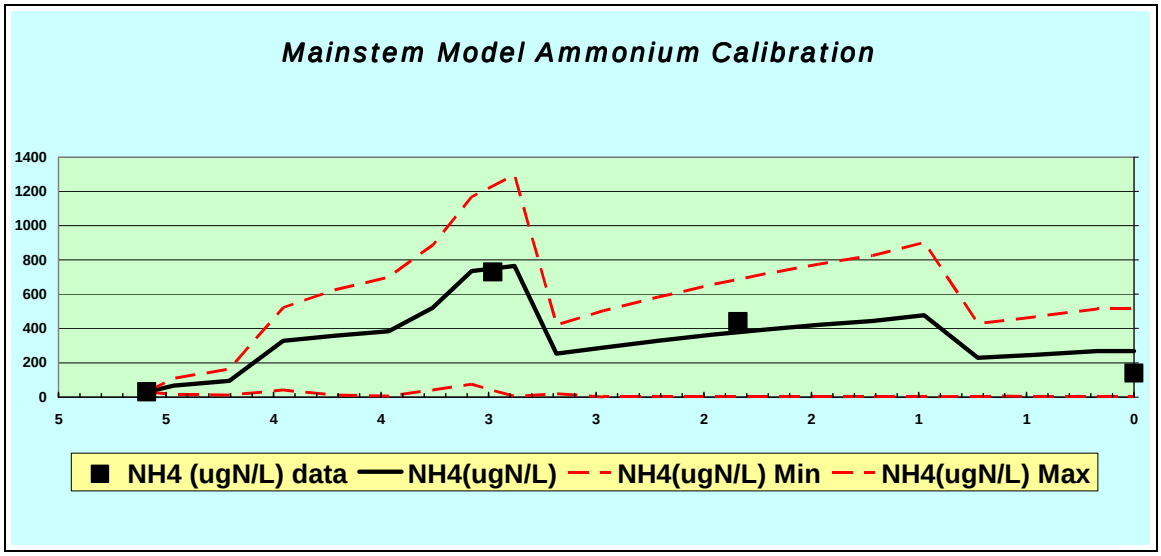


Figure 3-8: Total Phosphorus Calibration for the QUAL2K Mainstem Model

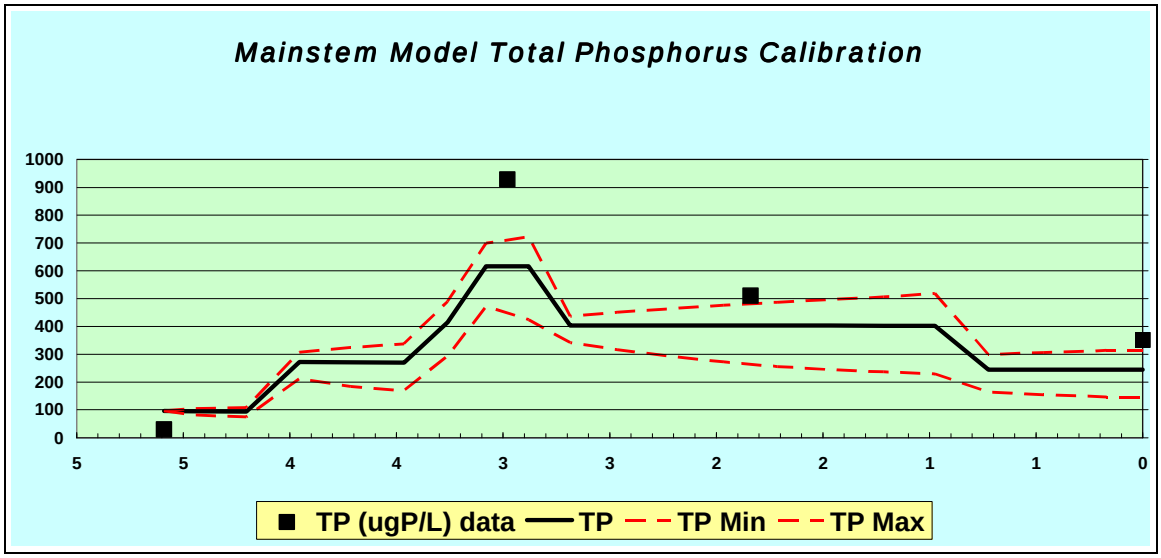


Figure 3-9: Temperature Calibration for the QUAL2K Mainstem Model

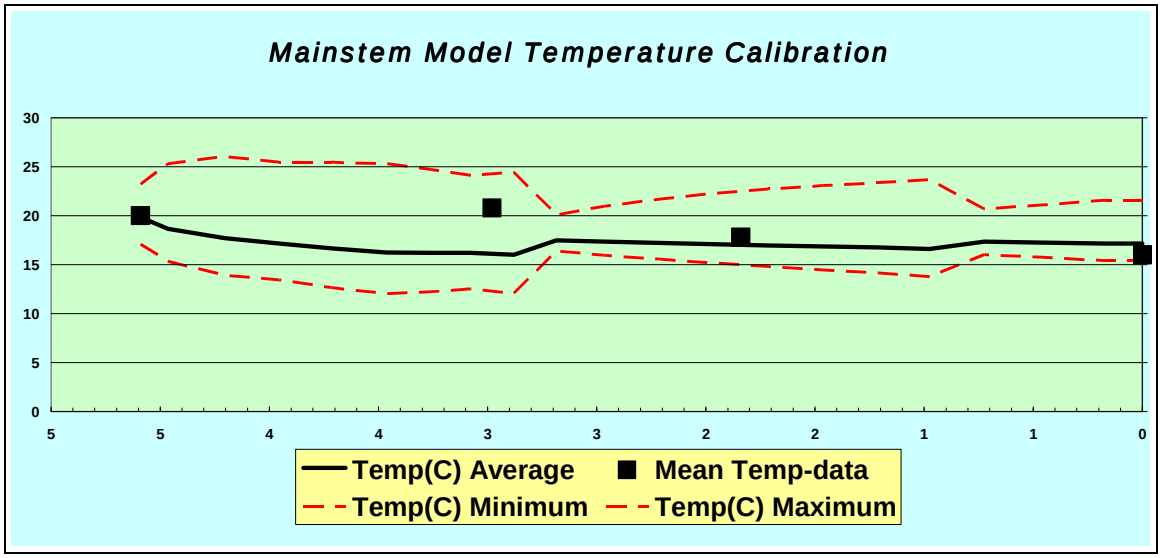
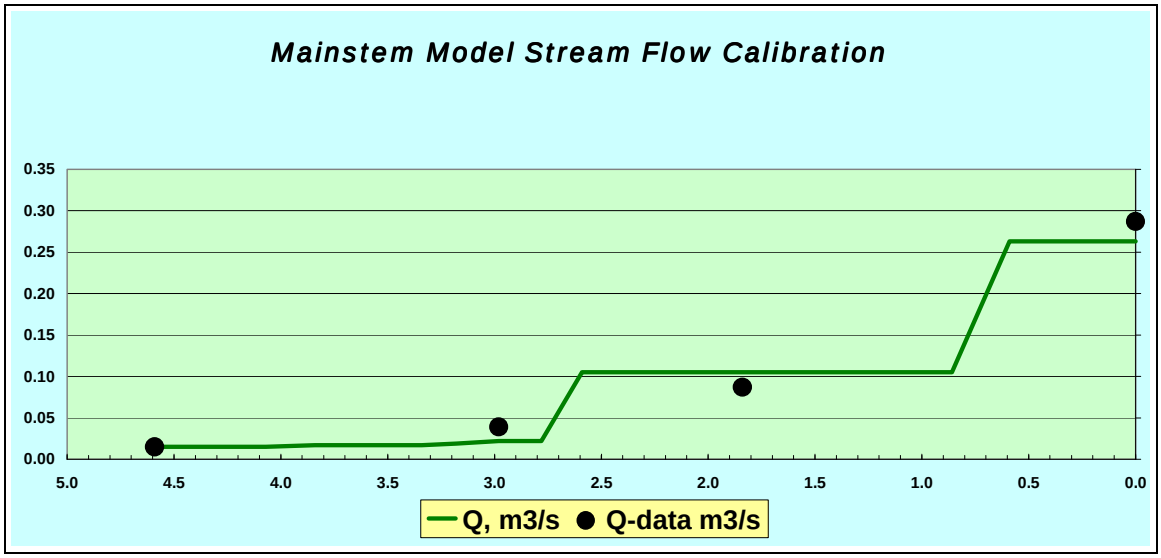


Figure 3-10: Stream Flow Calibration for the QUAL2K Mainstem Model



4.0 TMDL Endpoint Identification

TMDL development requires determination of endpoints, or water quality goals/targets, for the impaired waterbody. TMDL endpoints represent stream conditions that meet water quality standards. Endpoints are normally expressed as the numeric water quality criteria for the pollutant causing the impairment. Compliance with numeric water quality criteria, such as a maximum allowable pollutant concentration, is expected to achieve full use support for the waterbody. However, not all pollutants have established numeric water quality criteria. In these cases, alternative approaches may be used to define the TMDL endpoint.

Streams segments in Deep Run, Beach Run, and Elizabeth Run were initially included on Pennsylvania's 1996 Section 303(d) List of Impaired Waters as impaired due to excessive nutrient problems associated with point sources and agricultural activity in the watershed. Therefore, for TMDL development it is necessary to establish numeric endpoints for nutrients at which Deep Run, Beach Run, and Elizabeth Run are expected to attain their designated uses. As discussed in Section 1.0, Pennsylvania has a potable drinking water nitrate water quality standard. However, Pennsylvania currently has not established numeric criteria for phosphorus. Therefore, other means of determining the phosphorus TMDL endpoints were utilized. The approach used to define TMDL endpoints for phosphorus is discussed below.

4.1 Nitrate TMDL Endpoint

The Pennsylvania potable drinking water nitrate standard of 10 mg/L at the nearest drinking water intake was used as the nitrate TMDL endpoint for the Deep Run, Beach Run, and Elizabeth Run TMDLs. As presented in Table 2-8 and Figure 3-6, observed and modeled nitrate concentrations exceeded the 10 mg/L nitrate water quality standard at several points in Deep Run, Beach Run, and Elizabeth Run. However, the nearest drinking water intake, the Pennsylvania American Water Company, is 28 miles downstream, and is located on Swatara Creek near Hershey, Pennsylvania.

Analysis of the available flow data indicated that there is considerable dilution between the mouth of Elizabeth Run and the drinking water intake on Swatara Creek. The observed flow at the mouth of Elizabeth Run was approximately 10 cubic feet/second (cfs). Approximately 10 miles downstream of the Elizabeth Run mouth, the average flow at USGS station 01573000, Swatara Creek near Harper's Tavern, was 579.4 cfs. The closest flow monitoring station on Swatara Creek to the drinking water intake was USGS station 01573560, on Swatara Creek near Hershey, Pennsylvania. Mean stream flow at this station was approximately 1003.3 cfs. Due to the dilution occurring between the mouth of Elizabeth Run and the drinking water intake, the nitrate loads contributed from Deep Run, Beach Run, and Elizabeth Run are negligible with respect to nitrate concentrations at the drinking water intake. Additionally, water quality data collected at USGS station 01573560 for the available period of record (1984-1994) indicated that mean nitrate concentrations in Swatara Creek at this monitoring station were generally between 3-4 mg/L, and did not exceed 7 mg/L nitrate in any of the observed samples. This indicates that nitrate concentrations at the drinking water intake are below 10 mg/L, and thus do not violate the potable drinking water standard. For these reasons, TMDLs for nitrate were not required for Deep Run, Beach Run, and Elizabeth Run.

4.2 Phosphorus TMDL Endpoint

As stated above, Pennsylvania has not currently established numeric criteria for phosphorus. Therefore, because of the relationship between phosphorus and dissolved oxygen concentrations, the Pennsylvania instantaneous dissolved oxygen criteria of 4 mg/L was used as the TMDL endpoint for the Deep Run, Beach Run, and Elizabeth Run phosphorus TMDLs.

The linkage between instream nutrient levels, algae and dissolved oxygen concentrations was established by running the QUAL2K model under the dry weather, low flow condition, when elevated nutrient levels exert their largest influence on dissolved oxygen concentrations (Dodds, 2002). The maximum allowable phosphorus concentrations that did not violate the instantaneous dissolved oxygen criteria of 4 mg/L in Deep Run, Beach

Run, and Elizabeth Run were used as the target phosphorus concentrations upon which TMDL allocations were based. The target phosphorus concentration in Deep Run and Elizabeth was 337 µg/L, and the target phosphorus concentration in Beach Run was 257 µg/L. These concentrations are derived for the most stringent scenario, in which the point sources are discharging at their maximum capacities and their maximum permitted limits during low flow, dry weather conditions. Reduction of phosphorus loadings to these levels is expected to allow Deep Run, Beach Run, and Elizabeth Run to achieve their designated uses. Additional discussion of phosphorus reductions will be presented in Section 5.0.

4.3 Consideration of Critical Conditions

EPA regulations at 40 CFR 130.7 (c) (1) requires TMDLs to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that designated uses are protected throughout the year, including vulnerable periods.

In the case of Deep Run, Beach Run, and Elizabeth Run, a primary stressor pollutant in the streams is excessive nutrient loading. As stated in Section 4.2, the low flow, dry weather condition was identified as the critical condition in Deep Run, Beach Run, and Elizabeth Run. The QUAL2K model was setup to simulate the critical low flow condition, and the target phosphorus concentrations were established as the maximum phosphorus concentrations that did not result in violation of the Pennsylvania dissolved oxygen criteria under the critical condition. If the TMDLs are developed such that the water quality targets are met under the critical condition, then the water quality targets will be met under all other conditions.

4.4 Consideration of Seasonal Variability

Seasonal variations involve changes in stream flow and water quality as a result of hydrologic and climatological patterns. Seasonal variations were explicitly incorporated in the modeling approach for these TMDLs. AVGWLF is a continuous simulation model that incorporates seasonal variations in hydrology and nutrient loading by using a daily time-step for water balance calculations. Therefore, the 10 year simulation performed with AVGWLF adequately captures seasonal variations. Additionally, the QUAL2K model was run under both the wet weather, May condition, as well as the dry weather, low flow condition that was used to determine the target phosphorus concentrations.

5.0 TMDL Allocation

The purpose of TMDL allocation is to quantify pollutant load reductions necessary for each source to achieve water quality standards. Nutrients were identified as a primary pollutant in Deep Run, Beach Run, and Elizabeth Run. The potable drinking water nitrate standard of 10 mg/L represented the nitrate TMDL endpoint for Deep Run, Beach Run, and Elizabeth Run.

The instream phosphorus concentrations were established under the low flow critical condition using the instantaneous minimum dissolved oxygen standard of 4 mg/L as the TMDL endpoint. This represents the target phosphorus concentrations for Deep Run, Beach Run and Elizabeth Run under the most stringent, critical condition.

5.1 Basis for TMDL Allocations

TMDL allocations for Deep Run, Beach Run, and Elizabeth Run were based on the following equation:

$$TMDL = WLA + LA + MOS$$

Where:
TMDL= Target Phosphorus Concentrations under TMDL Endpoint
WLA = Wasteload Allocation
LA = Load Allocation
MOS = Margin of Safety

The wasteload allocation represents the total phosphorus loading allocated to point sources. The load allocation represents the total phosphorus loading allocated to non-point sources. The margin of safety is a required TMDL element to account for uncertainties in TMDL development.

5.1.1 Margin of Safety

An implicit margin of safety was used for Deep Run, Beach Run, and Elizabeth Run by using conservative estimates and modeling approaches.

5.2 Nitrate TMDL

The nearest drinking water intake is located about 28 miles downstream of the Deep Run, Beach Run, and Elizabeth Run watersheds. The available instream nitrate data at the Hershey, Pennsylvania USGS monitoring station (station 01573560), which is located upstream of the drinking water intake, was retrieved and analyzed. The data indicated that nitrate concentrations were generally between 3 to 4 mg/L at this monitoring station, and never exceeded 7 mg/L. In addition, comparison of stream flows at the mouth of Elizabeth Run to flows at USGS gage station 01573560 clearly indicated that there is significant dilution in the stream network. Therefore, the nitrate loads delivered from Deep Run, Beach Run, and Elizabeth Run will not have a significant impact on instream nitrate concentrations at the drinking water intake. On this basis, nitrate TMDLs will not be required for Beach Run, Deep Run and Elizabeth Run.

It is important to note that elevated concentrations of nitrate were observed in the groundwater monitoring data collected in the Deep Run, Beach Run, and Elizabeth Run watersheds. While it is not within the scope of this TMDL report to investigate the cause of the observed elevated concentrations, it is recommended that the sources of groundwater nitrate be identified and characterized.

5.3 Phosphorus TMDL Allocations

5.3.1 TMDL Allocation Scenarios

The target phosphorus concentrations under the dry weather, critical condition were identified as described in Section 4.0. It is important to recognize that these endpoints were developed under specific conditions which include the following:

- Permitted facilities are discharging at their design capacities
- Permitted facilities are discharging BOD, phosphorous, and ammonia at their maximum permitted levels
- Permitted facilities effluent DO concentrations only meet the minimum permit requirements

The combination of these factors resulted in target phosphorous concentrations that are very stringent and would require substantial phosphorus load reductions from point and non-point sources of phosphorous in the watersheds. Since it is not likely that all of these conditions will coexist in the watersheds, several scenarios to reduce permitted BOD, increase the DO concentration in the effluent, or simply maintain the status loadings were assessed. Using the QUAL2K model, additional loading scenarios were evaluated. These additional loading scenarios examined the impacts of other water quality parameters that influence the maximum allowable phosphorus concentrations that do not violate Pennsylvania's dissolved oxygen criteria. The scenarios considered are presented in Tables 5-1 and 5-2. Below is a brief summary of the key scenarios:

- Scenario 1 represents the most stringent condition which requires permitted point sources located on Deep Run to not discharge greater than 200 µg/L phosphorus, and permitted facilities on Beach Run to not discharge greater than 450 µg/L phosphorus.
- Scenario 2 requires permitted point sources to comply with a minimum effluent dissolved oxygen requirement of 7 mg/L under design flow conditions.
- Scenarios 3 and 4 represent reduction of BOD in the discharge effluent of the permitted point sources to 15 mg/L under design flow conditions.
- Scenarios 5 and 6 represent reduction of BOD in the discharge effluent of the permitted point sources to 10 mg/L under design flow conditions.
- Scenarios 7 and 8 represent the facilities discharging at their permitted limits under existing effluent flow conditions. Under this scenario, the existing discharge rates from the facilities would be maintained at their current rates.
- Scenarios 9 and 10 represent reduction of BOD in the discharge effluent of the permitted point sources to 15 mg/L under existing flow conditions

Scenarios 1 and 7 represent the loading conditions at the permitted water quality parameter levels but under two significantly different effluent flow conditions. Scenario 1 allows facilities to expand up to their potential design capacity; Scenario 7 limits the facilities to their existing effluent discharge rates.

Table 5-1: Phosphorus TMDL Allocation Scenarios for Deep Run and Elizabeth Run

Scenario No.	Facility Flow condition	Facility Permitted Ammonia Concentration (µg/L)	Facility BOD (mg/L)	Facility Dissolved Oxygen (mg/L)	Facility Permitted Phosphorus (µg/L)	Corresponding Instream Phosphorus (µg/L)
1	Design	3000	40	5	200	337
2		3000	40	7	4000	2740
3		3000	15	5	500	570
4		3000	15	7	4000	2740
5		3000	10	5	1000	898
6		3000	10	7	4000	2740
7	Existing	3000	40	5	4000	1100
8		3000	40	5	1000	578

Table 5-2: Phosphorus TMDL Allocation Scenarios for Beach Run

Scenario No.	Facility Flow condition	Facility Permitted Ammonia Concentration (µg/L)	Facility BOD (mg/L)	Facility Dissolved Oxygen (mg/L)	Facility Permitted Phosphorus (µg/L)	Corresponding Instream Phosphorus (µg/L)
1	Design	3000	40	5	450	257
2		3000	40	7	600	317
3		3000	15	5	500	277
4		3000	15	7	750	375
5		3000	10	5	550	297
6		3000	10	7	775	385
7	Existing	3000	40	5	850	371
8		3000	40	7	950	404
9		3000	15	5	1000	419
10		3000	15	7	1125	453

The proposed TMDL allocation scenarios that will allow Deep Run, Beach Run, and Elizabeth Run to attain their designated uses are presented above. The final TMDL allocation scenarios will be chosen after discussions with and in consultation with representatives from various state and local agencies, watershed stakeholders, and the public. Tentative TMDL allocations, based on allocation scenario 7 for Deep Run and Elizabeth Run, and based on allocation scenario 4 for Beach Run, are presented below. It is emphasized that these are tentative scenarios, with the final TMDL allocations to be determined after input from watershed stakeholders, state and local agencies, and the public.

5.3.2 Phosphorus Wasteload Allocation

The wasteload allocated to point sources in the watersheds was based on allocation scenario 7 for Deep Run and Elizabeth Run, and on allocation scenario 4 for Beach Run, in which modeled point source phosphorus concentrations did not result in violations of the instantaneous dissolved oxygen standard. These concentrations were multiplied by the existing flows of each facility in Deep Run, and the design flows for each facility in Beach Run, to compute the allocated phosphorus load for the point sources. For facilities discharging into Deep Run and Beach Run, their allocated load was 4000 µg/L, and 750 µg/L, respectively. Proposed phosphorus wasteload allocations are shown in Table 5-3.

Table 5-3: Proposed Phosphorus Wasteload Allocations for Permitted Facilities on Deep Run, Beach Run, and Elizabeth Run

Facility Name	Permit No.	Receiving Waterbody	Existing Load (lbs/year)	Allocated Load (lbs/year)	Percent Reduction
Keystone Protein Company	PA0080829	Beach Run	153.0	569.9[1]	0
BC Natural Chicken	PA0024228	Deep Run	1641.6	4995.3[2]	0
Farmer's Pride Poultry	PA0035157	Deep Run	4658.4	6105.4[2]	0
College Hill Poultry	PA0008010	Beach Run	732.4	342.0[1]	53
Fredericksburg Wastewater Treatment Plant	PA0080705	Deep Run	416.3	832.6[2]	0

1: Calculated using facility design flows
2: Calculated using facility existing flows

5.3.3 Phosphorus Load Allocation

No reduction in land based phosphorus loads is necessary to achieve the target phosphorus concentrations for Deep Run, Beach Run, Elizabeth Run, because dissolved oxygen concentrations did not violate water quality criteria under wet weather conditions. Rather, violations of the dissolved oxygen standards occurred under the design discharge flow conditions of the facilities in Beach Run, and under existing discharge flow conditions of the facilities in Deep Run and Elizabeth Run. The existing and allocated non-point source phosphorus loads for each source in the Deep Run watershed are presented in Table 5-4. Existing and allocated non-point source phosphorus loads for each source in the Beach Run watershed are presented in Table 5-5. Existing and allocated non-point source phosphorus loads for each source in the Elizabeth Run

watershed are presented in Table 5-6. No phosphorus reductions are required from land based sources in Deep Run, Beach Run, and Elizabeth Run under the allocation scenarios.

Table 5-4: Proposed Phosphorus Load Allocations for Deep Run

Source	Land Use Type	Deep Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	23.1	23.1	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	312.2	312.2	0
	Row Crop	303.4	303.4	0
	Low Intensity Residential	0.02	0.02	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.02	0.02	0
Septic Systems	-	0.0	0.0	0
Groundwater	-	2127.4	2127.4	0
Total		2766.4	2766.4	0

Table 5-5: Proposed Phosphorus Load Allocations for Beach Run

Source	Land Use Type	Beach Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	93.7	93.7	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	446.5	446.5	0
	Row Crop	896.7	896.7	0
	Low Intensity Residential	0.0	0.0	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.0	0.0	0
Septic Systems	-	1.9	1.9	0
Groundwater	-	2289.6	2289.6	0
Total		3728.7	3728.7	0

Table 5-6: Proposed Phosphorus Load Allocations for Elizabeth Run

Source	Land Use Type	Elizabeth Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	0.0	0.0	0
	Evergreen Forest	Not present	Not present	0
	Mixed Forest	0.0	0.0	0
	Pasture/Hay	695.9	695.9	0
	Row Crop	274.5	274.5	0
	Low Intensity Residential	0.4	0.4	0
	High Intensity Residential	0.2	0.2	0
	Commercial/Industrial	0.1	0.1	0
Septic Systems	-	3.8	3.8	0
Groundwater	-	619.0	619.0	0
Total		1593.8	1593.8	0

5.4 Overall Proposed Phosphorus TMDL Allocations

The load and wasteload allocations and margin of safety for Deep Run are summarized in Table 5-7. The load and wasteload allocations and margin of safety for Beach Run are summarized in Table 5-8. The load and wasteload allocations and margin of safety for Elizabeth Run are summarized in Table 5-9. Proposed allocations for each source in the Deep Run, Beach Run, and Elizabeth Run watersheds are provided in Table 5-10, Table 5-11, and Table 5-12. No reductions in phosphorus are required in Deep Run and Elizabeth Run under allocation scenario 7. No overall reductions in phosphorus are required in Beach Run under allocation scenario 4, although it is necessary to reduce phosphorus in the effluent of the College Hill Poultry facility under this proposed allocation scenario. Achieving the dissolved oxygen instantaneous standard for Deep Run and Beach Run under allocation scenario 7 requires the permitted facilities to maintain their discharge rates at their current levels. To attain the dissolved oxygen standard in Beach Run under allocation scenario 4, BOD levels must be maintained below 15 mg/L under design flow conditions. Tables 5-13 and 5-14 present the BOD reductions and effluent dissolved oxygen concentrations necessary for the permitted facilities under allocation scenarios 4 and 7.

Table 5-7: Proposed Phosphorus TMDL for Deep Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety
15700.4	3767.1	11933.2	Implicit

Table 5-8: Proposed Phosphorus TMDL for Beach Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety
4640.6	3728.7	911.9	Implicit

Table 5-9: Proposed Phosphorus TMDL for Elizabeth Run (lbs/year)

TMDL	Load Allocation	Wasteload Allocation	Margin of Safety
1593.8	1593.8	0.0	Implicit

Table 5-10: Proposed Phosphorus TMDL Allocations for Deep Run

Source	Land Use Type	Deep Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	23.1	23.1	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	312.2	312.2	0
	Row Crop	303.4	303.4	0
	Low Intensity Residential	0.02	0.02	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.02	0.02	0
Septic Systems	-	0.0	0.0	0
Groundwater	-	2127.4	2127.4	0
Point Sources	-	6716.3	6716.3	0
Total		9482.7	9482.7	0

Table 5-11: Proposed Phosphorus TMDL Allocations for Beach Run

Source	Land Use Type	Beach Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	93.7	93.7	0
	Evergreen Forest	0.1	0.1	0
	Mixed Forest	0.2	0.2	0
	Pasture/Hay	446.5	446.5	0
	Row Crop	896.7	896.7	0
	Low Intensity Residential	0.0	0.0	0
	High Intensity Residential	0.0	0.0	0
	Commercial/Industrial	0.0	0.0	0
Septic Systems	-	1.9	1.9	0
Groundwater	-	2289.6	2289.6	0
Point Sources	-	885.4	885.4	0
Total		4614.1	4614.1	0

Table 5-12: Proposed Phosphorus TMDL Allocations for Elizabeth Run

Source	Land Use Type	Elizabeth Run Average Annual Phosphorus Load (lbs/year)		Percent Reduction
		Existing	Allocated	
Land Sources	Deciduous Forest	0.0	0.0	0
	Evergreen Forest	Not present	Not present	0
	Mixed Forest	0.0	0.0	0
	Pasture/Hay	695.9	695.9	0
	Row Crop	274.5	274.5	0
	Low Intensity Residential	0.4	0.4	0
	High Intensity Residential	0.2	0.2	0
	Commercial/Industrial	0.1	0.1	0
Septic Systems	-	3.8	3.8	0
Groundwater	-	619.0	619.0	0
Point Sources	-	0.0	0.0	0
Total		1593.8	1593.8	0

Table 5-13: Dissolved Oxygen Reductions Required Under Allocation Scenarios 4 and 7

Allocation Scenario	Facility Name	Flow Condition	Permitted Effluent Dissolved Oxygen (mg/L)	Proposed Effluent Dissolved Oxygen (mg/L)
4	College Hill Poultry	Design	5	7
	Keystone Protein Company	Design	5	7
7	BC Natural Chicken	Existing	5	5
	Farmer's Pride Poultry	Existing	5	5
	Fredericksburg Wastewater Treatment Plant	Existing	5	5

Table 5-14: BOD Reductions Required Under Allocation Scenarios 4 and 7

Allocation Scenario	Facility Name	Flow Condition	Permitted Effluent BOD (mg/L)	Proposed Effluent BOD (mg/L)	BOD Percent Reduction
4	College Hill Poultry	Design	40	15	63
	Keystone Protein Company	Design	40	15	63
7	BC Natural Chicken	Existing	40	40	0
	Farmer's Pride Poultry	Existing	40	40	0
	Fredericksburg Wastewater Treatment Plant	Existing	40	40	0

6.0 Reasonable Assurance and Implementation

There is reasonable assurance that the goals of these TMDLs can be met with proper watershed planning, implementation of pollution reduction best management practices (BMPs), and strong political and financial mechanisms. Reasonable assurance that the TMDLs established for nutrients will require a comprehensive, adaptive approach that addresses:

- point and non-point source pollution,
- existing and future sources,
- regulatory and voluntary approaches.

TMDLs represent an attempt to quantify the pollutant load that may be present in a waterbody and still ensure attainment and maintenance of water quality standards. The Deep Run, Beach Run, and Elizabeth Run TMDLs identify the necessary overall load reductions for phosphorus currently causing use impairments and distribute those reduction goals to the appropriate sources. Reaching the reduction goals established by these TMDLs will only occur through changes in current land use practices, including the incorporation of best management practices (BMPs), and monitoring to ensure that discharge effluent from permitted point sources does not exceed permitted or allocated water quality standards.

By developing TMDLs for the Deep Run, Beach Run, and Elizabeth Run watersheds, the stage has been set for local citizens to design and implement watershed restoration plans based on the reduction goals specified in the TMDLs. Interested parties should contact the appropriate watershed manager in the PA DEP's Southcentral Regional Office (717-705-4700) for information regarding technical and financial assistance currently available. Individuals and/or local watershed groups interested in helping to solve the identified problems in the Deep Run, Beach Run, and Elizabeth Run watersheds are strongly encouraged to avail themselves of funding sources available through DEP and other state and federal agencies.

The relative contribution of nutrients varies throughout the watershed according to the distribution of land use sources such as row crop and pasture lands, as well as the location of permitted point sources. Implementation of best management practices in the watershed and should reduce the non-point source loads of nutrients to levels that will assist in achieving the loading reduction goals established in these TMDLs. Because of the complexity of the problem and the potential solutions, an adaptive approach will be needed to achieve the TMDLs.

6.1 Implementation Funding Sources

Potential funding mechanisms for implementation include federal grants (i.e., CWA Section 104(b)(3), CWA Section 319, State Revolving Fund), and state grants (i.e., Growing Greener, PENNVEST). EPA funds are available through Pennsylvania under CWA Section 319 or the Non-point Source Program to fund some projects.

Growing Greener provides state funding as the mechanism to fund projects under Section 319. The DEP Southwest Regional office has also placed a high priority on activities to better control nutrient loading, reflecting the strong public interest in the area.

7.0 Public Participation

The development of the Deep Run, Beach Run, and Elizabeth Run TMDLs would not have been possible without the participation of the public and various state and federal agencies.

A public meeting will be held in the town of Fredericksburg, Pennsylvania on June 29, 2004 to discuss TMDL development for Deep Run, Beach Run, and Elizabeth Run, the 303(d) listing and identified pollutants, the methodology employed to determine watershed loadings of the pollutants, and the draft TMDLs. Copies of the presentation will be available for public distribution. The meeting will be public noticed. The public will have the opportunity to comment on the draft TMDL report, pollutant loadings, and the proposed allocation scenarios. Public comments will be received and addressed by EPA Region 3.

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